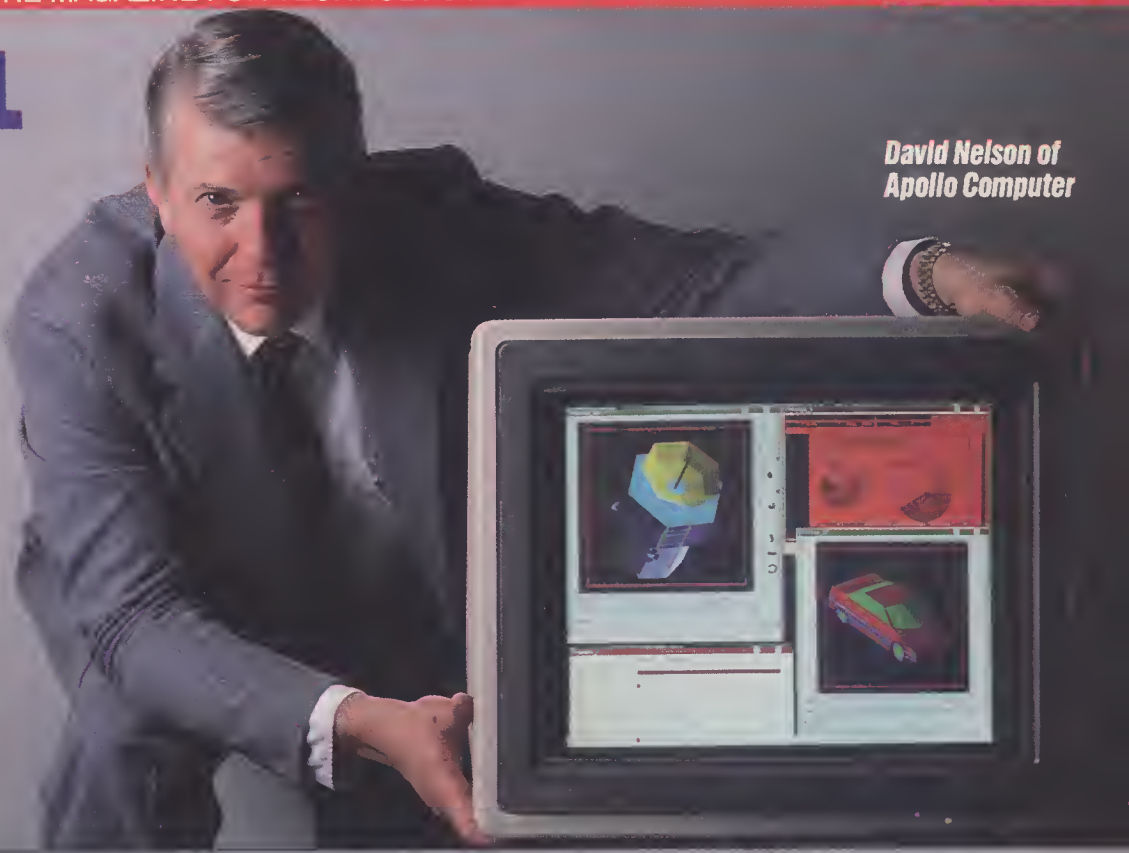
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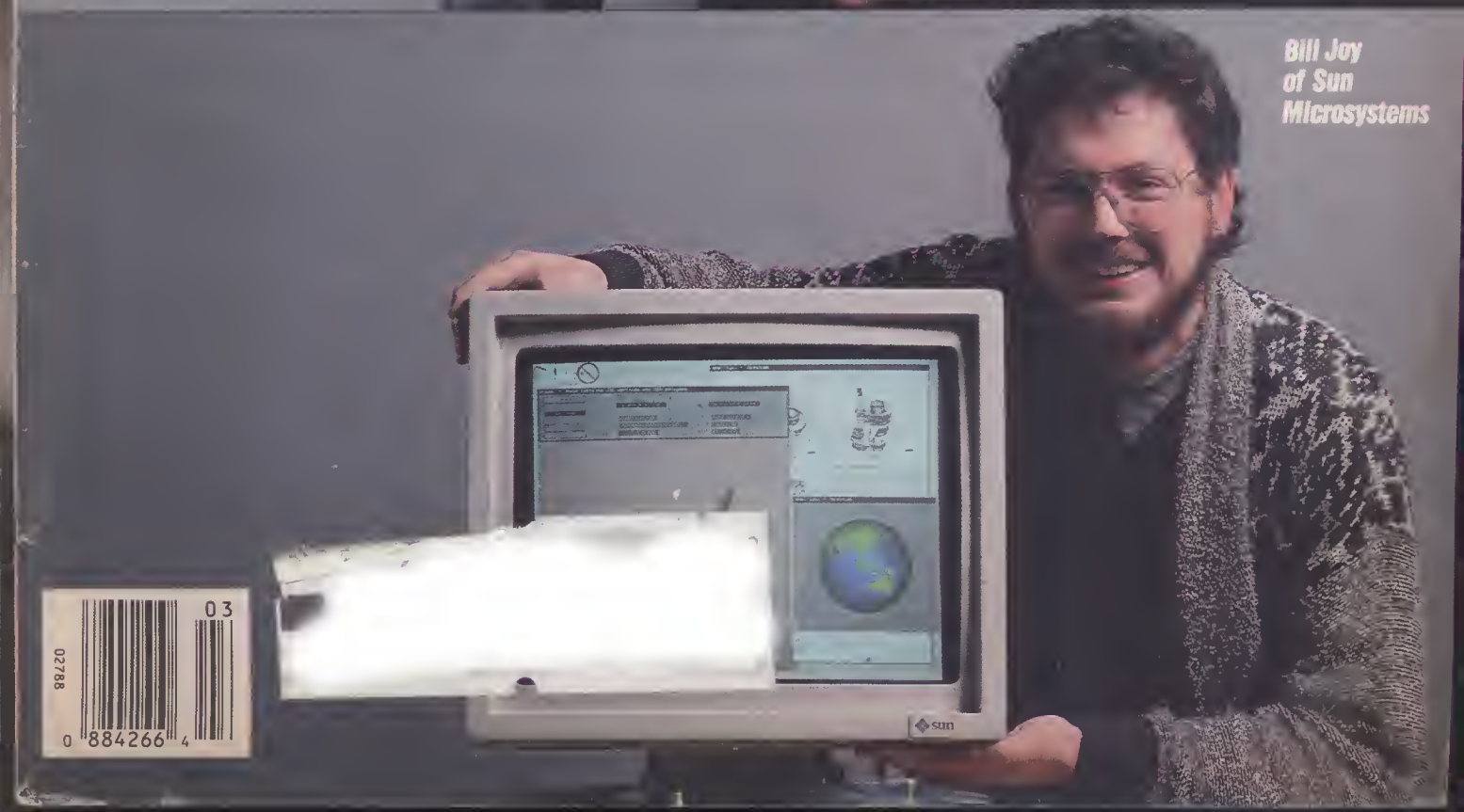
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PERSONAL WORK-STATIONS
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WILL JAPAN LAUNCH A COMMERCIAL AIRCRAFT INDUSTRY?



David Nelson of Apollo Computer



Bill Joy of Sun Microsystems

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C&C
Computers and Communications

NUMBER 137

1.3-MICRON OEICs FOR GIGA-BIT LINKS.

Scientists at the NEC Optoelectronics Research Laboratory have successfully tested the world's first optoelectronic ICs to operate in the 1.3μm band at data rates of 1.2Gbps.

The optical transmitter and receiver chip pair set records of a 12-km communication at 1.2Gbps with a 7.7dB margin, and 22-km transmission at 565Mbps with a 9.9dB margin in the experiment using a single-mode fiber.

The new light-emitting chip incorporates a 1.3μm DC-PBH (double-channel planar buried heterostructure) laser diode and three InGaAsP/InP hetero-junction bipolar transistors on the same InP substrate. Modulation up to 2Gbps is possible in NRZ mode. A peak output of 20mW was marked at 1Gbps.

The optical receiver integrates a PIN photo diode and three low-noise InGaAsP junction FETs on a single chip for sensitivity of −14dBm at 1.2Gbps.

NEC's new OEIC pair will be the ideal workhorse in medium- or short-distance ultra-high speed links including LANs, local subscriber loops and interconnections of computers and peripherals because it promises much lower cost and smaller size than prevalent discrete devices.

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NEC OPTICAL REPEATERS GO TRANSPACIFIC AND SUBMARINE.

The trend in transoceanic submarine cable systems is undeniably "optical". The use of fiber optic transmission technology increases capacity, extends repeater span and ensures compatibility with land-based digital networks.

Under a contract awarded by KDD, Japan's leading international telecommunications network, NEC is manufacturing optical submersible repeaters and optical terminal equipment for the third Trans-Pacific Cable (TPC-3) which will link Hawaii and Japan with a branch to Guam.

The TPC-3, to be completed in 1988 and owned by 22 telephone operating companies in 10 countries, will have two 280Mbps systems, offering a total capacity equivalent to 7,560 telephone channels—a dramatic increase from 138 channels with TPC-1 and 845 channels with TPC-2.

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THE GM ODYSSEY: SCIENCE NOT FICTION

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MARCH 1987

HIGH TECHNOLOGY

VOL. 7, NO. 3









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Bill Joy, Cofounder & Vice-President for R&D, Sun Microsystems. Photo by Clark Dunbar.

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TIME TO ROUSE THE SLEEPING GIANT

At one time American manufacturers had the U.S. marketplace almost to themselves. But many nations with growing industrial economies began to look beyond their own borders, and were lured by the huge potential of the U.S. market. Cheaper labor gave them some advantage, but to truly compete, they still had to match or exceed the technological advantages of U.S. companies.

Now this is happening. Japan and, more recently, Korea, Taiwan, and other nations moving up the technological scale have become world-class competitors. Yet the U.S. has done little to adjust its system to this new global marketplace.



FRED LYNCH

As a result, American manufacturers face some severe handicaps. They often produce goods on machinery that is older and less efficient than that of their new competitors. They pay much higher wages, and must hew to tougher regulations—on pollution and safety, for example. Not surprisingly, more and more products bought by U.S. consumers are made overseas. Here are a few things the U.S. needs in order to increase its competitiveness:

- Modern, smoothly working factories and offices that make effective use of available technology.
- Low-cost capital, to provide industries that must modernize with the equipment and plants they need.
- An efficient, well-trained workforce, hardworking and dedicated to the success of their organizations.
- Enough technically trained managers and professionals to keep industry innovative and competitive.
- Skill at moving innovative ideas from the lab to the workplace.
- Policies that encourage innovative new enterprises, particularly in the emerging technologies that will be tomorrow's growth industries.

This list is a far cry from today's actual U.S. agenda. Many industry leaders continue to conduct business as usual, or they close domestic plants and move manufacturing offshore. Government "leaders" focus on the wrong issues, seemingly unaware of the real problems.

For example, over 200 small biotech companies have sold their innovative technologies—at a minimal price—to overseas conglomerates in order to stay afloat (a repetition of the pattern for innovative semiconductor technologies). Congress has passed legislation lowering tax rates in spite of fast-rising deficits, doing almost nothing to remove the tax system's bias toward borrowing rather than saving, and removing incentives for capital spending. Rather than choosing a technology adviser, the President has selected a science adviser with a space-program background, who can serve as point man on SDI.

Our economy has been propped up for several years now by excessive federal deficits, paid for in large part by borrowing from overseas. Yet a strong U.S. economy is as important to those selling into our market as it is to American citizens; our trading partners often express amazement at the ineptitude of U.S. leadership in dealing with obvious economic problems. Fortunately, there is a lot of resilience left in the U.S. economy. Let's wake the sleeping giant before it's too late.

Robert Haavind

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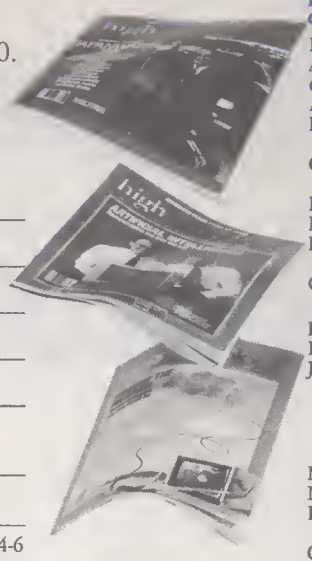
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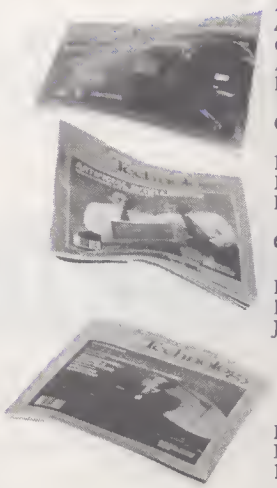
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A full-featured phone

In "Phone security for the rest of us" (Nov. 1986, p. 60), you refer to Motorola's government secure telephone unit (STU-3) as a "no-frills version" deskset. But the STU-3's speed dialing, selectable voice/

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Kevin G. Harding, Senior Researcher
Advanced Manufacturing Technologies Laboratory
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graphs were swapped—GE's Norman Melburney and Coopers and Lybrand's Walter Ulrich.

We welcome comments from our readers. Please address letters to Editor, High Technology, 38 Commercial Wharf, Boston, MA 02110. Or send to MCI Mailbox: HIGHTECHLET.

IMAGE BY MICHELLE AMATO

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amazement at the ineptitude of U.S. leadership in dealing with obvious economic problems. Fortunately, there is a lot of resilience left in the U.S. economy. Let's wake the sleeping giant before it's too late.

Robert Haavind

FRED LYNCH

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Wanted: Enlightened managers

In "Seeing the light in manufacturing" (Oct. 1986, p. 13), Ronald C. Reeve chose to ignore what should have been obvious during his travels in Japan and the U.S.—it is more productive to have young and experienced people work as a team instead of replacing one with the other. It is also far more practical for a company to keep experienced people up to date through continuing education than to try solving problems by turning over the staff. With such policies, companies can gain more value from their experienced employees, and immediate contributions from their new people, instead of waiting "five to ten years."

Leonard R. Kasday
East Windsor, N.J.

Reeve states that manufacturing engineering staffs "are simply unable to respond to the challenges that manufacturers now face," and that we should "relax and let this new generation of manufacturing engineers lead us back to competitiveness."

I have worked primarily as an industrial engineer for 20 years and have found that the major roadblock to improving productivity is the rigid attitude of managers. No engineering staff can lead a foot-dragging management to places that it does not want to go.

Regardless of the engineers' generation, only management can create an atmosphere that encourages individuals to contribute creative ideas that increase productivity. A new managerial approach—the deliberate pursuit of change—is critical to the resurgence of American manufacturing competitiveness.

Gregory B. Gardner
Ojai, Cal.

A full-featured phone

In "Phone security for the rest of us" (Nov. 1986, p. 60), you refer to Motorola's government secure telephone unit (STU-3) as a "no-frills version" deskset. But the STU-3's speed dialing, selectable voice/data modes, plain old telephone (POT) operation without power, adjustable data rates, and programmable configurations hardly sounds like no-frills.

Timothy Hall, FSVS Marketing Manager
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Keeping an eye on stereoscopic vision

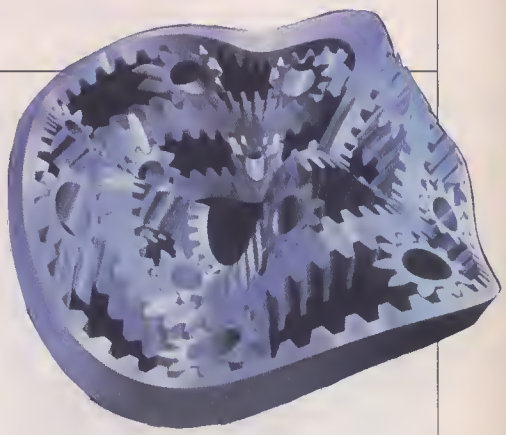
"Two-eyed robots" (Nov. 1986, p. 64) made some good points regarding the need for 3-D vision. Many problems with inspection, measurement, and guidance in industry that are inherently 3-D could be corrected with the addition of some degree of depth-perception information. However, I believe that the conclusion of your article—that stereoscopic vision is the way to go—is premature.

One limitation of stereoscopic vision is that it typically relies on key features in the scene to correlate images from the two cameras' perspectives. In areas with no distinct features, there can be no stereo matching. This is true for parts such as stamped metal or plastic panels. Moreover, the correlation operation used in stereo matching is difficult to effect, because different perspectives of the same object may appear much different or may actually present different features due to obscurities.

Another limitation of stereo viewing is imposed by the geometry and resolution of the cameras. Viewing an object that is far away (compared to the depth variations in the object and the separation of the cameras) will often present an image pair with no distinct differences. (Look at a distant tree out your window).

Another way to sense distance is through a laser range finder. Because it does not require two different views of an object, it can look down a hole where two lines of sight would be impossible. This system has been used for some time for looking at distant military targets; several commercial versions are already on the market.

Kevin G. Harding, Senior Researcher
Advanced Manufacturing
Technologies Laboratory
The Industrial Technology Institute
Ann Arbor, Mich.



"Gears" was the first-place winner in the experimental category of NCGA's Computer Graphics '86 International Computer Animation Competition.

IMAGE BY MICHELLE AMATO

A graphic overstatement

In "Graphics conference on videotape" (Dec. 1986, p. 6), you state that Siggraph is "the computer graphics industry's leading exposition." However, each year the National Computer Graphics Association (NCGA) sponsors an exposition with more exhibitors, floor space, and attendees than any other computer graphics exposition. Last year NCGA's Computer Graphics '86 attracted 35,000 people, 266 exhibitors, and covered 135,000 square feet. Siggraph '86 attracted 22,000 people, 250 exhibitors, and covered 105,000 square feet. The major companies that attended our show and were missing from Siggraph's were Applicon, CalComp, Comtal/3M, IBM, ISSCO, McDonnell Douglas, Polaroid, and Tektronix. We expect similar success at Computer Graphics '87 in Philadelphia on March 22–26.

Phillip S. Mittelman, President
National Computer Graphics Association
Fairfax, Va.

On p. 19 of "The electronic mailbox: As close as your PC" (Jan. 1987), captions for two photographs were swapped—GE's Norman McBurney and Coopers and Lybrand's Walter Ulrich.

We welcome comments from our readers. Please address letters to Editor, High Technology, 38 Commercial Wharf, Boston, MA 02110. Or send to MCI Mailbox: HIGHTECHLET.

INNOVATIONS

Expert advice for factory managers

In making decisions on factory operations, manufacturing executives often need to juggle a large number of variables. Computerized models can simulate the effects of different variables on the functioning of a plant, but most executives lack the time and expertise to run them. A new artificial intelligence package may remedy the situation. Called Operations Advisor, it reportedly helps managers make production decisions quickly and with a minimum of fuss. The new package, from Palladian Software in Cambridge, Mass., is an expert system, containing knowledge gleaned from specialists and a set of rules for applying that knowledge. Geared to executives from plant engineers on up—in industries that manufacture discrete products (as opposed to materials)—the Operations Advisor sells for $136,000 and runs on special-purpose processors from Symbolics and Texas Instruments.

The user enters details like product lot sizes and cost per unit, the number and types of workstations, the time each needs to finish a task, and the hours they're scheduled to run. Because the program is designed to account for the fluctuations and uncertainties typical of manufacturing, it accepts the highest, lowest, and most likely figures for a given variable, and can incorporate such nuances as the cost differences between, say, the second shift on Monday and the first shift on Saturday. The Operations Advisor can then determine, for example, how much it will cost the plant to increase output, or what effect a new robot may have on the overall operation. At the same time, it may identify potential problems the user might have overlooked, such as the effect that changes in one product may have on another product that shares the same workstations.

Since it's meant for a manfucturing executive and not a computer expert, the program is menu-driven, requiring no special commands. In fact, says Palladian vice-president Themis A. Papageorge, it comes without a user manual; it's designed to explain itself in everyday language.



Workers at Saab in Sweden remove a car roof panel as it exits Asea's Flexforming press. The use of a single die half (beneath the panel) allows short-run models to be produced faster.

Flexible presses stamp out cars

As competition in the auto industry heats up, carmakers are trying to develop new models faster and more efficiently, as well as to attract customers through limited-edition models that may differ substantially from standard designs. Recognizing this trend, Asea Pressure Systems (Birmingham, Mich.) has developed new sheet-metal stamping presses that make small production runs more economical and allow designs to be changed faster than with conventional methods. The company's Flexforming system requires only one die half, saving manufacturers the time and cost of making two precisely matched halves.

Replacing the second die half is a flexible diaphragm backed by a reservoir of hydraulic oil that, when pressurized, forces the sheet metal to conform to the shape of the die. Flexforming has been used to make small parts since the 1950s, but Asea has adapted the technique to its high-pressure Quintus presses, which are big enough and sturdy enough for stamping the large, complex parts needed in the auto industry.

According to Asea, Flexforming permits a wider variety of shapes, since it can reproduce contours and cavities not possible with rigid die halves that must engage and disengage. The company also claims that the technique reduces the time needed to prepare dies for limited-run parts from several months to a few weeks and cuts the cost of stamping parts for prototypes (much of which stems from getting the two die halves to mesh perfectly) by as much as 90%. However, says Nilsson, the method loses its cost-effectiveness when a large number of parts are needed, because it cannot match the speed of conventional sheet-metal presses.

Germany's BMW and Sweden's Saab have already begun to use Flexforming, and Asea says it is now talking to major automakers in the U.S.

Laser turntable saves record wear

The age of digital audio may be looming, but don't throw out your old LPs yet. The scourge of vinyl records is the stylus, which exerts a pressure of 20,000 pounds per square inch, wearing down the tracks and grinding dust into the surface. To remedy this problem—and the attendant loss of sound quality—a turntable developed by Finial Technology in Sunnyvale, Cal., eliminates the stylus. Instead, it plays records with a low-power laser, à la compact discs.

As laser light strikes the vinyl surface, it is modulated by the waveform embedded in the groove. The analog signal carried by the reflected light is then read by an optical detector. Tracking is accomplished by high-speed servo-controlled mirrors that keep the laser beam locked onto the groove even if the turntable is jolted, or if the record is warped.

Finial's marketing manager, Michael May, says the turntable not only helps keep new records in mint condition but makes worn discs sound better. A stylus,

he says, wears down only the portion of the groove walls that it actually touches. But the laser pickup reads the entire groove, including the part that a stylus has left intact. The result is a cleaner signal. What's more, says May, small scratches or dust particles produce virtually no noise, and larger defects register only as a brief click.

The turntable, scheduled for release this month, provides such audiophile performance at an audiophile price: $2500.

Industrial-strength Velcro

Screws and rivets may join children's shoelaces in the list of standard fasteners being supplanted by Velcro. In a new, heavy-duty version of the familiar bristles-and-fuzz, a pad of woven stainless-steel wire is engaged by an array of novel metal hooks developed by Foster-Miller (Waltham, Mass.). As in conventional nylon Velcro, the hooks readily snag the loops, allowing the pieces to stick together on light contact.

Employing techniques similar to those used to make integrated circuits, Foster-Miller has fabricated hooks in several shapes—such as *J*s and arrowheads—using strong, heat-resistant metal alloys. The resulting structure, whose manufacture the company hopes to license, has 10 times the sticking power of nylon Velcro; it takes a force of more than 100 pounds per square inch to pull the two halves apart. In some cases, says senior staff consultant Paul J. Marinaccio, the metal Velcro is strong enough to replace ordinary metal fasteners for holding pieces of a product together. And it's particularly suitable for automated assembly, he says, because a robot can slap Velcro in place much more easily than inserting a screw.

The tight bond exacts a cost, however: each time the pieces are separated, some of the loops or hooks break. Thus while nylon Velcro lasts for many thousands of cycles, says Marinaccio, the metal version wears out after only a dozen or so cycles. But for many products, he maintains, such a limitation is unimportant: "How many times are you going to take apart your washing machine?"

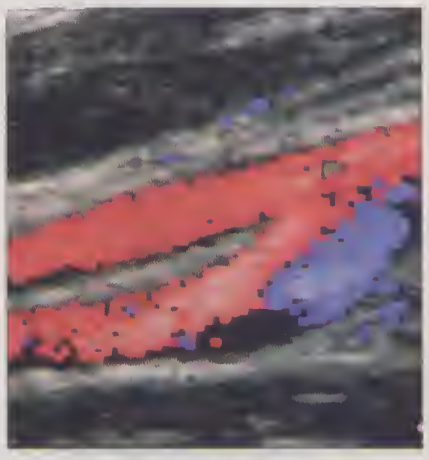
Metal plating with salt

A novel coating technique can plate metallic or insulating materials with a wide range of metals, including ultrahard, heat-resistant (refractory) elements such as tungsten and titanium. The process, being developed by MIT materials science and engineering professor Donald Sadoway, has several advantages over existing methods. Electroplating, for example, works only on conductive materials and cannot deposit most refractory metals; and vapor deposition, which avoids these shortcomings, requires a vacuum, corrosive gases, and temperatures as high as 900° C.

In the MIT process, the metal to be deposited is dissolved in molten salt (typically 300–400° C), and the piece to be coated is immersed in the hot bath. Cooling the salt forces some of the metal to crystallize out of solution, forming a thin, even film that chemically bonds to the submerged surface. One potential application is to metallize ceramic so that it can be attached to metal parts with conventional brazing techniques; the metal-to-metal bond could survive repeated temperature cycling better than a ceramic-to-metal connection. Another possible use is in coating soft or corrosion-prone metals with more durable ones. Sadoway says that commercialization of the technique is being pursued by MIT's Technology Licensing Office.

Imager monitors the bloodstream

Accurate measurement of blood flow is invaluable in pinpointing circulatory disorders. Yet the standard imaging methods have serious drawbacks. For example, angiography, in which injected dyes are tracked by x-ray, is highly invasive; and in ordinary ultrasonic imaging, which is noninvasive, defects such as constrictions are often hard to detect, and arteries can't be distinguished from veins. Now, an enhanced ultrasonic technique developed by Quantum Medical Systems (Portland, Ore.) can indicate the flow's speed—making defects easier to spot—as well as its direction.



QAD-1 imaging system displays arteries in red, veins in blue. The lighter the color, the faster the blood flow.

Like conventional ultrasonic imaging, the new method, known as angiodynography, uses a hand-held transducer that emits megahertz-range sound waves into body tissue and forms images from the echoes. But angiodynography goes a step farther. A computer examines the doppler shift in the echoes from the bloodstream—the changes in frequency that occur as the stream moves toward or away from the transducer—and then adds color to show the motion of the blood. In the resulting real-time images of vessels, blood moving away from the transducer (in the arteries) is colored red, and blood moving toward it (in the veins) is colored blue. Defects are signaled by paler or darker color, which signifies faster or slower blood flow.

One user of Quantum's QAD-1 angiodynography system, W. Dennis Foley, professor of radiology at the Medical College of Wisconsin, says the technique not only allows constricted or blocked vessels to be located faster and more accurately but makes small vessels easier to see. He adds that it is especially useful in determining whether an organ transplant has been accepted (as shown by an increase or decrease in blood flow) and in making preoperative evaluations of blood vessels, such as those that will be used in heart bypass surgery.

Since July 1986, says Ray Powis, Quantum's marketing manager, some 20 systems have been sold, at $175,000 each.

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PLAGUE OF THE PAPER PUSHERS

LEE A. IACOCCA
CHAIRMAN AND CHIEF EXECUTIVE OFFICER
CHRYSLER CORP.

If nothing else, Ivan Boesky has fired up the debate over the value of corporate raiders and their camp followers, the arbitrageurs. Are these guys really Robin Hood and his Merry Men, as they claim to be? Or are they Genghis Khan and the Mongol hordes?

All I know is what I see, and what I don't.

I see billions of dollars tied up in new corporate debt to keep the raiders at bay while research and development goes begging. I see billions going for greenmail that ought to be building new, high tech factories. I see confidence in Wall Street's integrity lower than at any time since the big crash.

I also see a huge share of America's best management talent wasted on takeover games when it should be devoted to strengthening the industrial base of the country.

But I don't see the raiders creating jobs. I don't see them increasing productivity. And worst of all, I don't see them doing a thing to help America compete in the world.

I hear their holier-than-thou pitch about making companies more efficient, liquefying capital, and defending the helpless stockholder. But a funny thing happens to these dedicated missionaries once you cross their palms with a little dough—they go away!

If these people are really interested in saving American business from its incompetent management, where were they back in 1980 when Chrysler was flat on its back? One thing I never had to worry about in those days was a raider coming around, because Chrysler wasn't worth looting.

The typical takeover target isn't a company in trouble. It's a company with a solid asset base, low debt, consistent profits, and a few bucks in the bank to diversify or get through the next business downturn.

When I went to school, we called that "good management." Today it makes you fair game. Choosing to modernize your factory instead of increasing your dividend might make good business sense, but it's also like putting fresh blood in the water: it draws the sharks. So when the raiders and the "arbs"—people who buy



huge chunks of stock to hold for a couple of days or weeks, looking for a windfall—get involved, you're forced to do things that make no business sense at all just to stay alive.

My interest in all this started getting too close to home this fall when two of Chrysler's biggest suppliers, USX and Goodyear, found themselves "in play."

It's hard to exaggerate the importance of suppliers in my business—especially the ones providing the steel and rubber. They're really "partners." A supplier who

Management talent is spent on takeover games instead of on strengthening the industrial base.

doesn't make his commitment can shut all our factories down in just a few days.

So naturally I got worried. I didn't know what the raiders had in mind for my partners. Were they just going to grab the assets and run? Were they going to pocket the R&D budget? Did they give the slightest damn about servicing me? Did they even know one single thing about my business, and how important these suppliers are to me?

Maybe the biggest question of all: would they force me to go overseas for materials I'd rather see produced by American workers?

I still don't know the answers.

Goodyear managed to survive the raid. It only cost them $2.6 billion. They'll just have to sell off a few subsidiaries, close some plants, put some people on the street, and load their balance sheet with new debt. Meanwhile, Sir James Goldsmith, the guy playing Robin Hood, said, "I'm walking out of this with my head held high," after aborting his raid. Maybe the cool $90 million or so he got in greenmail helped him keep his head high.

No doubt about it, the raiders push up stock values and make some people (mostly themselves) a great deal of money. But if quick paper profits replace long-term competitiveness as the prime reason to invest in American industry, then I don't want to think where we're heading as a nation.

The people getting rich in a hurry in America today are not the ones putting more efficiency into our factories or modernizing our steel mills; they are these paper pushers on Wall Street.

American entrepreneurship, which used to be based on building better mousetraps, seems to be giving way to leveraged buy-outs and junk bonds. It's becoming a great big Monopoly game with real money.

If this keeps up, Wall Street is going to foul its own nest, and we'll all be the losers. The American securities market lubricates our whole economy. We can't afford to smother it with too many regulations, but we also can't afford to let it be manipulated by people out for a quick and dirty buck.

Mr. Boesky has guaranteed that Congress will take a close look at Wall Street this session. It's time to at least slow down the action. One good idea I've heard involves a waiting period: make somebody wait six months after they buy stock before they can vote it. Most raiders won't tie up their money that long. They're not risk takers at heart. They only bet on sure things.

And a waiting period is fair. We make people register to vote a month or two in advance because we don't even want our dogcatcher to be elected by somebody who happens to be passing through town

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on a bus. I don't want American business controlled by people who ride through in the middle of the night with a fistful of stock certificates that they intend to sell first thing in the morning.

Corporate raiders talk piously enough about making American business more efficient, but what they have in mind is rape. And that often makes businessmen too nervous to think about the legitimate and sensible acquisitions and mergers that can actually help companies become more productive and competitive.

I know because we've been trying to diversify Chrysler for the past couple of years. We've made four friendly acquisitions and we're looking for more.

But we're not going to kidnap anybody into the family. When I paid off the federally guaranteed loans three years ago, I said, "Chrysler borrows money the old-fashioned way: we pay it back." Well, when it comes to courting, we like to do it the old-fashioned way, too—we like to knock on the front door with candy and flowers.

Raiders talk piously about making American business more efficient, but what they have in mind is rape.

These days, though, with all these raiders running loose, everybody is scared to answer the door. Even a simple phone call can send a company to battle stations. And if you say you'd like to stop by and talk, they fill the moat and pull the drawbridge.

Companies are paranoid today, and you can't blame them. CEOs are trying to plan ahead while they're looking over their shoulders. Some of them are spending more time fighting off the raiders who are trying to take over their companies than they are fighting off the Japanese and Germans who are taking over their markets.

That's no way to run a business, and that's sure as hell no way for America to compete. □

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A hand-held infrared viewer helps reduce losses for a large insurer of boiler machinery. Insurance company engineers use Hughes' Probeye® infrared viewer to survey plants of applicants and policyholders. The Probeye viewer sees heat the way a camera sees light, converting it instantly into an image seen through the eyepiece. Inspectors check for potential hazards in piping systems, electrical connections, and pressure vessels. Infrared viewers are valuable tools for paper manufacturers, too. Moisture in paper sheets must be monitored continually during processing, since sharp differences can result in serious defects. The viewers pick up temperature changes caused by varying moisture conditions, enabling operators to stop the process and make corrections.

Now in "storage" in a 22,300 mile-high orbit, Mexico's second communications satellite is awaiting the day in about three years when it will be called into service. Morelos B, one of the Hughes HS 376 lines of satellites, has undergone routine testing. It will serve as a spare for several years because the first Morelos spacecraft now provides sufficient coverage for Mexico's communication needs. The Morelos satellites are the first HS 376 spacecraft with expanded capabilities of operating simultaneously in two frequency bands, the C- and Ku-bands.

A new electronic "road map" will enable pilots of helicopters and small tactical fighters to fly safely over unfamiliar territory without the need to wrestle with flight charts. The Integrated Terrain Access and Retrieval System (ITARS), under development by Hughes for the U.S. Air Force, will display color-coded surface features and man-made structures. By touching a button, the pilot can show terrain data in look-down or look-ahead views. The system will share its stored data with other systems aboard the aircraft to aid in navigation, terrain following and avoidance, weapon delivery, mission planning, and threat avoidance.

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CHEYENNE SOFTWARE:

LETTING PARTNERS DO THE SELLING

Several years ago, a management consulting group within Chemical Bank (New York) jury-rigged a mainframe software program to analyze white-collar productivity at the bank. "We then realized that if we could bring it down to the personal computer level and make it user-friendly," recalls John McCabe, director of marketing for the bank's Information Products Division, "we could sell this software to outside users." Lacking the proper resources, the Chemical Bank team turned to Cheyenne Software. The Roslyn, N.Y., firm produces specialized software that is then marketed by the company that commissioned it.

"Product development and marketing skills are distinctly different," says Barry Rubenstein, Cheyenne's chairman. "We go to people who already know how to market in their particular industry and offer to develop software for them." This division of labor is not unique in the vertical application software field, which will generate an estimated $3.4 billion in sales by 1990, according to Future Computing (Dallas).

What is unusual is Cheyenne's financial arrangement with its partners. The company charges partners an up-front fee that is about 10% of what other developers charge, and makes its profits on subsequent royalties ranging from 15 to 40% of product sales.

Chemical Bank paid Cheyenne $75,000 for work on its product, Organization Rx; McCabe estimates that any alternative would have cost around $750,000. This software sells for $15,000 per copy, which Rubenstein translates into a potential market of $100 million; his firm's share will be based on royalties in the range of 25–40%. "If this product fails, I'm not out a significant amount of money," says McCabe; "and if it succeeds, then both Cheyenne and Chemical Bank come out winners."

Cheyenne generally seeks partnerships with Fortune 1000 corporations, major franchises, software publishers, and large value-added resellers with substantial customer bases (in such markets as law, real estate, and healthcare) and firmly established national distribution channels. In addition to Chemical Bank, the company has negotiated marketing partnerships with Automated Legal Systems (Philadelphia) to develop a database tool for litigation paralegals, Fisher Business Systems (Atlanta) for medical management software, and Globe Information Systems (Tampa, Fla.) for ticketing software used for concerts and sporting and theatrical events.

Fueling Cheyenne's development efforts is a library of hundreds of programming routines and modules, including generic versions of a word processor, database, query language, and report writer. Cheyenne engineers can develop software applications to client specifications in 10–15% of normal development time, claims Rubenstein, by hooking together modules already tested and debugged. In addition, all software produced by Cheyenne is integrated and has the same user interface; partners can thus market a product line with a consistent look and feel.

Cheyenne has a year or two head start over the competition for a potentially large market that has barely been tapped, says Peter Lynch, director of research at New York–based brokerage Grady & Hatch. Moreover, he adds, "the company doesn't take any risk itself, because its partners are paying Cheyenne to design something they know the market wants." And with partners like Chemical Bank, Lynch believes that Cheyenne has the credibility to walk in anywhere. □

—Anita Micossi



Chemical Bank's John McCabe turned to Cheyenne Software to commercialize the bank's management productivity program.

ESM INTERNATIONAL:

SCANNING THE FOOD INDUSTRY

ESM International (Houston) has cultivated a niche in food processing for the kind of optical-scanning devices normally used for quality-control functions on assembly lines. ESM's machines are used for sorting agricultural commodities such as soybeans, peanuts, rice, tomatoes, carrots, almonds, and coffee beans. Recently, the company joined its scanners with mechanical cutting systems to produce the Hydrocutter, a machine that can sort and slice french-fried potatoes.

The french-fry industry, whose market leaders include H. J. Heinz's Ore-Ida subsidiary, J. R. Simplot, and Carnation, dishes up more than 4.7 billion pounds a year, according to the American Frozen Food Institute. At such a scale—5 million pounds of potatoes pass through a typical plant each day—the process of carving away black spots and other imperfections, which consumers find distasteful, is a large drain of manpower. ESM saw a potential market for high-speed optical-sorting equipment that could automatically detect and slice off such unwanted material.

The Hydrocutter channels each french fry through a stream of water that shoots through a clear plastic tube. As the french fry passes through the tube, optical sensors locate its defects, which are snipped off by a 90-blade cutting wheel capable of 1000 slices per second. Cuts as small as a quarter of an inch can be made, which makes for less waste, and each machine can be linked to a personal computer for tracking production rates and quality-con-

trol measures. ESM developed the sorting technology and water-conveyor system for the Hydrocutter, and Justus Bros., its West German partner, contributed the cutting mechanism.

Savings from use of the $81,000 Hydrocutter on a typical french-fry production line amount to an estimated $250,000 a year, according to ESM. The company sees a potential $20 million North American market for potato machines like the Hydrocutter.

ESM was purchased for $3 million in 1984 from Moorco International, a Houston-based manufacturer of oil-field tools, by a holding company owned by Pat Childress, now ESM's president. "I thought it was an unusual opportunity to acquire undervalued assets," says Childress. ESM earned $6.5 million in revenues in fiscal 1985, after losing money in the early 1980s, before Childress purchased it.

The company now intends to upgrade some of its other optical sorting products with microprocessor-based monitoring and control components, depending on the firm's analysis of government agricultural spending and food consumption trends. For instance, when Congress approved the Farm Bill of 1985, ESM decided to produce a new rice-sorting machine, knowing that federal legislation would boost rice farmers' income through heavy subsidies. ESM is also analyzing new markets for its optical-scanning products outside the food industry. But, says Childress, "our main interest will continue to be the food business because it's always going to be there." □ ***—Elizabeth Willson***

ARITY:

BRINGING AI TO BUSINESS APPLICATIONS

Arity (Concord, Mass.), a software firm spun off from Lotus Development in 1984 to design artificial intelligence programming tools, is planning to broaden its product offerings by starting a line of AI-based application software for the business community. Industry observers speculate that the first such product to be released this year will be in the decision support system arena, a category of software that enables managers to process and manipulate large amounts of data for such purposes as financial planning, production scheduling, and resource allocation.

The company's new products will almost certainly be written in Prolog so that they can be tailored by customers using Arity's existing line of compilers, interpreters, and expert-system development packages, among other tools. "Arity has the most complete Prolog-based AI development package available for personal computers," says Harvey Newquist, an analyst with AI market research firm D. M. Data (Scottsdale, Ariz.), making the company a leading firm in the current $10 million Prolog segment of the $30 million AI programming language market.

As it moves into the application world, Arity faces uncertainties about its future relationship with Lotus and the competitive status of Prolog. Mitch Kapor, Lotus's chairman and founder, resigned from the boards of directors of both Lotus and Arity late last year. Kapor provided a major impetus for Lotus's original interest in AI, and supported the financing by Lotus of part of Arity's first round of funding, according to Carol Weiszmann, editor of *AI Markets* (Natick, Mass.). "Kapor's departure from Arity's board might have been problematic two or three years ago," she says, "when AI start-ups needed the visible backing of an established firm." But now, AI is regarded as a legitimate field in its own right, she feels. Moreover, Arity never had joint marketing or development agreements with Lotus that would be endangered by Kapor's departure, points out Peter Gabel, Arity's chairman. "If anything, Arity will now have a broader range of contacts with Lotus," he says. "Before, it was just us and Mitch."



JONATHAN GOELL

Arity will pursue commercial clients while continuing to serve programmers, says chairman Peter Gabel.

Another issue involves competition between Prolog and other programming languages. Lisp programs, which are based on lists and emphasize increased programmer control, are favored in the U.S., while Prolog products, which rely on database-like queries and emphasize speed, are employed extensively in Europe and Japan. Specialized computers are needed to execute Lisp quickly, but are not needed for Prolog. All in all, Gabel believes that Prolog retains the edge because it is the faster language for personal computer applications.

Arity plans to restructure itself into two divisions: one for tools, which will continue to cater to programmers; and the other for applications, which will pursue business clients. If Arity manages to sell to both markets, it will be one of the first software firms to successfully do so. Weiszmann says it is logical for the company to try. "The tool market is limited, and Arity already has ties to the PC world." Gabel agrees. "Tools are just a stepping-stone for us; we're really a PC applications company," he says. □ ***—Mary Jo Foley***

THE NEW OHIO ENTREPRENEURS



Rodger Gamblin wants newspapers to come clean

U.S. newspapers consume 300 million pounds of ink a year. And a lot of it comes right off on your hands. Publishers are looking for new kinds of inks that not only eliminate smudging but also reduce paper waste and improve printing quality. Enter a Gamblin man from Dayton—Rodger Gamblin, to be precise. He found that dye-based inks have the ability to solve all these problems. But they need to be made cheaper and better.

Teaming up with the University of Dayton Research Institute, Gamblin received a $250,000 grant from the State of Ohio's Thomas Edison Program. With a matching private investment, Gamblin formed Saranda Corporation to demonstrate the advantages of dye-based inks for newspapers and to go after a market estimated at $150 million.

Rodger Gamblin is a new Ohio entrepreneur. There are hundreds of others like him—using innovative technologies to create jobs and new businesses. For information on how the Edison Program can help you—wherever you live—develop your new advanced technology products or process in Ohio, call Christopher Coburn, Executive Director, Ohio's Thomas Edison Program, at 1-800-345-OHIO, or use the coupon below.



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PERSONAL WORKSTATIONS



LOU JONES

REDEFINE DESKTOP COMPUTING

By Jeffrey Bairstow

Compact machines link business or technical users to vast data-processing resources

The personal workstation is a relatively new arrival in the computing world—the first commercial units, from Apollo Computer (Chelmsford, Mass.), Sun Microsystems (Mountain View, Cal.), and Xerox Information Systems (Pasadena, Cal.), appeared in 1981. Providing almost mainframe-level computing power for around $50,000, they were an instant success, enthusiastically adopted by software developers for designing both system and application software, by electronics engineers for computer-aided design, and by a wide range of businesses for technical publishing.

Last year, more than 57,000 workstations were sold, making up a $1.5 billion market. By 1990, says analyst Kathleen Hurley of Dataquest (San Jose, Cal.), close to 350,000 workstations will be sold annually—a $4.5 billion market with a 37% annual growth rate—driven in large part by new applications such as mechanical engineering design, financial analysis, and factory automation. Indeed, in almost

Two proud fathers of personal workstations, David Nelson of Apollo Computer (left) and Bill Joy of Sun Microsystems, with their offspring.



CLARK DUNBAR

any creative activity where people have to interact with each other and with computers, the workstation is becoming an essential tool.

Workstations are full 32-bit computers—usually with sophisticated graphics displays, a keyboard, and a mouse, and usually attached to a high-speed network. The network gives rapid access to other users (and to files and data on their workstations), to massive data storage, and, often, to mainframe computers or even supercomputers. Consequently, workstation users have at their fingertips computing power exceeding that of a personal computer by several orders of magnitude.

For example, mechanical engineers can use their workstations to design, analyze, and simulate products, and even to generate the instructions for driving the machine tools that will make the products' parts. Until recently, such operations would have required several computers and entailed difficult translations from one software package to another. Now, one engineer can produce designs with a drafting or solid-modeling package physically located on another's workstation; all the engineers on the network have access to the same software and can share design files. Thus an initial design can be sent to a specialist for stress analysis using a finite-element analysis program (perhaps with the aid of a mainframe computer attached to the workstation network), and then returned to the original designer. In this way, workstations become essential links in design efforts for groups working on complex projects. By using such techniques, General Motors expects to halve the conventional five-year design cycle for a new car model.

Future increases in workstation performance and network transmission speeds will simplify the user's interaction with the computer still further. The workstation will become, in effect, a sophisticated control panel linked to a network of other workstations and a variety of computers. A single application might call for some computation on a supercomputer, analysis on a parallel processor, or assistance from an artificial intelligence machine. This use of different processors and software packages—network computing—will require little direction from the user; the workstation will essentially decide where and how the application will be executed. Although the initial applications of network computing will be in science and engineering (the traditional workstation markets), the same techniques can be applied to business as well.

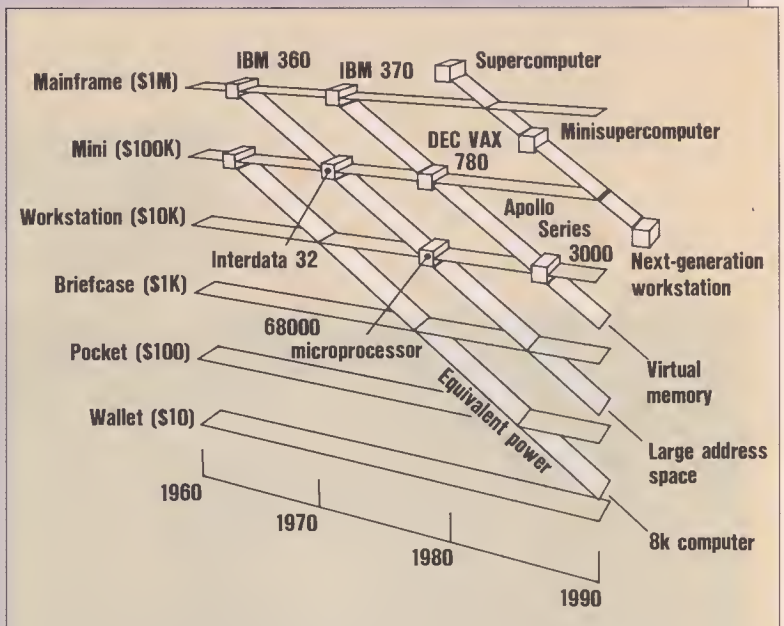
The most popular workstations are made by Apollo and Sun, largely because they were the first entrants in the marketplace and offer considerable computing power for a low price. Xerox has been much less successful because its first models, although sophisticated, were much more expensive. The other two major workstation makers are Digital Equipment Corp. (Maynard, Mass.), with the MicroVAX, and Hewlett-Packard (Fort Collins, Colo.), with the HP 9000 series, both relatively recent entries into the field. IBM (Milford, Conn.) has also entered the market recently with its RT Per-

Downward Migration Of Computer Technology

In predicting future developments in computer technology, David Nelson, chief technical officer at Apollo Computer, classifies computers into seven tiers, each separated from the other by a factor of 10 in cost (see chart). The aggregate improvement in performance across the tiers is about 35% a year, so a tenfold improvement (across one tier) occurs every seven years. Thus the virtual-memory capability of a $1 million IBM 370 mainframe computer, which first emerged in 1970, became available on the DEC VAX in 1977 (for approximately $100,000) and in the Apollo DN300 workstation in 1984 (for approximately $10,000). By extrapolation, claims Nelson, that same capability ought to be available in 1991 for close to $1000.

At the higher end of the workstation market, he says, there will be increasing performance for constant cost. Thus a $50,000–$100,000 workstation, which approaches the performance of a mainframe today, should have the capabilities of a minisupercomputer, such as the Alliant, by 1991.

Nelson also believes that a tenfold performance increase is matched by a weight decrease of the same order. "Computers seem to cost about $200 per pound, independent of their size," says Nelson, "a figure that has been valid for the last 30 years when adjusted for inflation." As computers become more of a "commodity," perhaps one day it will be possible to buy them by the pound.



The multi-tier model is a good predictor of when concepts will appear, but a poor predictor of how the concepts will be used, says Apollo's David Nelson. "For example, although the model accurately predicts virtual-memory development, the importance of local-area networks for workstations would have been difficult to estimate."

SOURCE: APOLLO

CHARTS BY MARK ALSOP

sonal Computer and 5080 Graphics System. Japan's NEC is also moving into the U.S. market with an engineering workstation priced lower than Apollo's or Sun's. More specialized workstations for computer-aided engineering in electronics are made by such companies as Daisy Systems (Mountain View, Cal.) and Mentor Graphics (Beaverton, Ore.) and for mechanical design by Cognition (Billerica, Mass.) and Aries Technology (Lowell, Mass.), often using special-purpose hardware. However, many such vendors are moving toward offering their software on general-purpose workstations as the power of those machines increases.

The device that made the personal workstation possible was the 32-bit microprocessor, notably the Motorola 68000 series, which allowed system designers to address large amounts of memory and to use sophisticated concepts, such as virtual memory, previously possible only on much larger computers. The 68000 series of chips also permitted the development of low-cost bit-mapped computer graphics, where each screen pixel has a specific memory location, providing very high screen resolution and rapid drawing rates. "For less than $20,000," says David Nelson, one of the originators of the workstation concept and now the chief technical officer of Apollo Computer, "a user can have a 1.4-mips [million instructions per second] workstation with up to 4 megabytes of memory, a 72-megabyte hard disk, and a color graphics display that's 1024 lines by 800 columns."

Such performance, notes Nelson, is roughly equivalent to that of a Digital Equipment VAX, the de facto standard scientific and engineering workhorse computer of a few years ago. Nonetheless, Nelson and other leading workstation designers see today's models as only the first steps toward putting phenomenal computing power on the desktop. At Sun Microsystems, Bill Joy, cofounder and vice-president for R&D, describes the workstations based on the Motorola 68000 as "the first generation." Says Joy, "I foresee a second generation of workstations that will use inherently faster RISC [reduced instruction set computing] processors, with performance beginning at about 10 mips roughly in 1987 and exceeding 100 mips by 1992." (See chart, p. 21.) Because they perform fewer operations per instruction than a conventional computer, RISC microprocessors execute programs faster. RISC architecture and improvements in the speed of CMOS (complementary metal-oxide silicon) chips should enable the design of such 100-mips workstations, predicts Joy.

One of the first high-performance RISC-based workstations is expected early this year from Prime Computer (Natick, Mass.). The new system will use RISC processor boards developed by aptly named MIPS Computer Systems (Sunnyvale, Cal.), whose founders were previously involved in a RISC design project at Stanford University. Prime is attempting to match the MIPS processor with a specialized graphics processor developed by Silicon Graphics (Mountain View, Cal.), a small, innovative manufacturer of very-high-performance graphics displays and systems. However, industry observers claim that Prime is delaying the introduction of the new workstation until more software has been developed, a key problem for new entrants in the workstation marketplace. Other high-performance workstations are expected this year from two small start-ups, Stellar Computer (Wellesley, Mass.) and Dana Computer (Sunnyvale, Cal.).

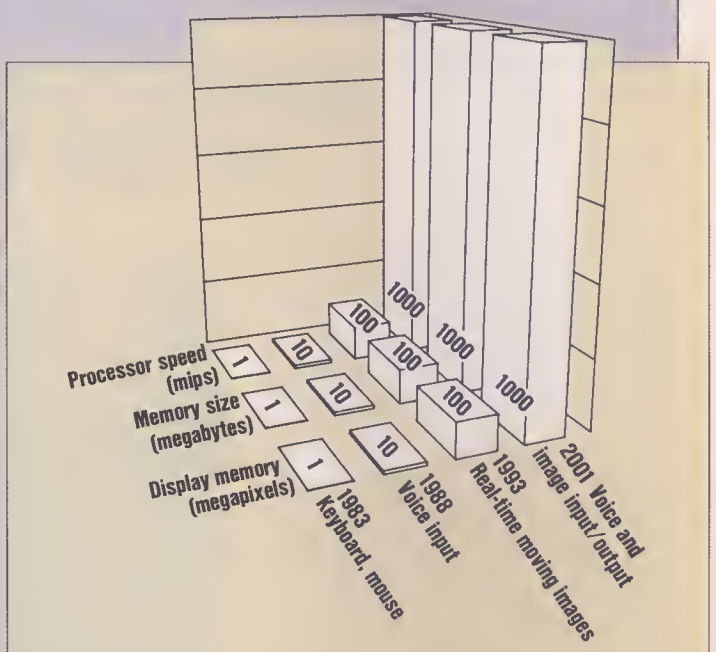
When 100-mips workstations do begin to appear, says Joy, they will have programmable graphics processors to display complex curved surfaces with good lighting and shading models, now possible only with very large computers and expensive graphics displays. They should be

FUTURE WORKSTATION PERFORMANCE

The first generation of workstations, typified by those widely available today, is coming to an end, claims Bill Joy, Sun Microsystems' co-founder and vice-president of R&D. A second generation of workstations, beginning roughly in 1987, will offer 10 times the processor speed, 10 times the memory size, and 10 times the display capability (see chart). This generation will use inherently faster RISC (reduced instruction set computing) processors. Further improvement might be expected from very-high-speed CMOS chips or gallium arsenide. Thus, predicts Joy, another generation of workstations can be expected in 1993 with a similar tenfold improvement in performance and capability.

These new workstations will have programmable graphics processors to display complex curved surfaces with realistic lighting and shading, and to show documents with presentation-quality graphics. They should be able to handle moving images in real time. Networking via fiber optics will be possible, using the full ISO set of protocols. Such machines will be powerful enough to use artificial intelligence techniques whenever appropriate.

By the year 2001, predicts Joy, $15,000 (in today's dollars) will buy a truly cognitive machine with such good voice and image input/output that a keyboard will no longer be necessary. "Such a machine," he says, "would have at least 24 color planes and could show complex images at movie speed [24 frames per second], maybe with stereo sound and display."



Some startling increases in workstation performance are predicted by Sun Microsystems' Bill Joy—starting in 1988 with a second generation running at 10 million instructions per second (mips), as well as offering 10 megabytes of memory and 10 megapixels of display capability. Further tenfold leaps will come with successive generations in 1993 and in 2001.

SOURCE: BILL JOY

able to handle moving images in real time. Users will be able to show documents using presentation graphics, with half-tone images and precise representations of typefaces. "Such machines will be powerful enough to use artificial intelligence techniques where appropriate," says Joy.

Indeed, AI applications are already beginning to appear on workstations. Inference Corp. (Los Angeles) has developed a workstation-based expert system for American Express that can conduct sophisticated credit checks previously posible only with the expertise of a senior corporate officer. Such financial and business applications are a new area of activity for workstations. "I believe that workstations are just beginning to make an impact on corporate America," says Don Sinsabaugh, managing director of Swergold, Chefitz and Sinsabaugh, a New York–based investment company. With the increases in computing power that workstations will shortly bring, AI applications like intelligent stock trading systems and rule-based merger and acquisition systems will become available to a much wider marketplace.

But will the other key aspect of workstations—the network—be able to keep pace with such dramatic increases in processor performance? Joy at Sun Microsystems is equally optimistic on this subject: "Today, the phone companies are laying down fiber optic networks, so 100-megabit-per-second transmission rates are perfectly feasible. I see no reason why fiber optic networks should not go to 200 or 300 megabits per second by 1990." With some image compression, perhaps by sending only the differences between successive images, such data rates would allow images to be sent directly between workstations or computers anywhere in the world; image compression of 10:1, for example, effectively multiplies the data transmission rate tenfold, making image transmission feasible. Another possibility would be direct memory-to-memory transfers of large amounts of data or programs between machines with fiber optic links.

In addition, all the workstation vendors are moving toward common network standards for the interconnection of a variety of networks and computers. Most support Sun's Network File System (NFS) protocol, which runs on all the operating systems of computers in a network, allowing the sharing of files and the interoperation of computers from different vendors. A similar but more limited standard is AT&T's RFS (Remote File Sharing), an extension to UNIX that allows the sharing of UNIX resources, both files and devices, transparently across a network. In the longer term, workstation vendors are preparing to support the ISO seven-layer protocols that will allow systems and applications to be interconnected pretty much at the will of the user. Given such improvements in networking capability, industry experts predict that the workstation makers will soon find extensive demand for their systems in large businesses.

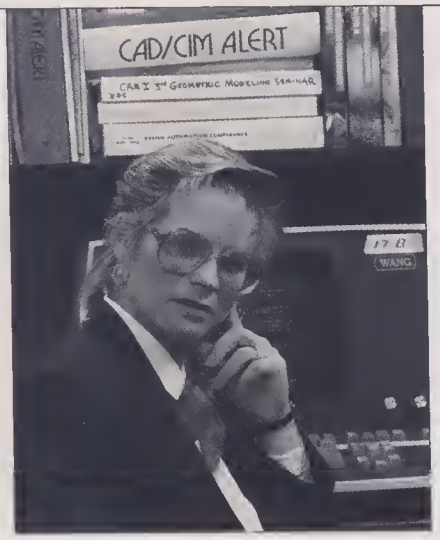
But the introduction of very-high-performance workstations and networks may be slowed by the lack of suitable operating systems and application software. Today, the predominant operating system for workstations is UNIX (developed at Bell Laboratories), which has gained wide acceptance in science and engineering but has been slow to find business application, largely because it is cryptic and "user-surly." Further complicating matters, UNIX comes in two quite dissimilar versions—AT&T's System V, based on the original Bell Labs work, and the Berkeley 4.2BSD system, developed at the University of California at Berkeley. The two versions are sufficiently different that several workstation vendors feel obliged to offer both. Thus a workstation might display a program using the AT&T UNIX on one window and a program using the Berkeley UNIX on another window—a situation

WORKSTATIONS REACH FOR NEW MARKETS

Fueled by falling prices and increasing computing power, the market for personal workstations has been rapidly expanding in recent years. Revenues from such machines—generally defined as 32-bit, stand-alone, desktop devices—will total an estimated $1.5 billion in 1986 and should climb to $4.5 billion by 1990, according to Dataquest (San Jose, Cal.). Some 80% of this market is dominated by four companies: Apollo Computer (Chelmsford, Mass.), the 1986 market leader, followed by Sun Microsystems (Mountain View, Cal.), Digital Equipment (Maynard, Mass.), and Hewlett-Packard (Fort Collins, Colo.).

Price and performance factors have played a major role in workstation market growth, points out Vicki J. Brown, program manager of CAD/CAE/CAM at International Data Corp. (IDC) in Framingham, Mass. "Between 1982 and 1987, the average system price of a workstation fell from $50,000 to $20,000," she says, "while computational power in this price range has doubled." As a result of such trends, workstations are now more versatile, and are available to a broader population of users.

This market's fastest-growing segments are particularly dependent on the kind of computing and graphics capabilities previously available only from minicomputer or mainframe systems, says Gary Smaby, managing director of the high technology group at Piper, Jaffray, and Hopwood (Minneapolis). In technical publishing, for instance, users want to see exactly how a page will look when published; they can do this with the high-resolution, 19-inch screens featured on many high-performance workstations. Superior graphics are also important to software developers, who can employ such workstations to design easy-to-use, highly flexible software products for financial and other business applications. And mechanical engineers can exploit the computing power of workstations to analyze how the products they are designing might behave under varying conditions.



SETH RESNICK

"Over the past year, major workstation vendors have been adding DOS capabilities to their products so that a user can switch from CAD/CAM to personal computer–type applications on the same machine."

Vicki J. Brown
CAD/CAE/CAM Program Manager
International Data Corp.

"Because of their continuing productivity gains, workstations should be the most common mode of computing in the business world within ten years."

Christopher Reed
Technical Marketing Manager
Digital Equipment

Another factor stimulating the growth of workstations is their utility as both single-user machines and access points to larger networks. "An individual can get greater responsiveness from a machine under his control than if he has to share computing resources through a multi-terminal system," says IDC's Brown. At the same time, she adds, workstations can be integrated with other computers and factory automation tools. Such networks facilitate communication within groups involved in common projects, and, with appropriate application software, enable designers to send the results of their work directly to the shop floor.

The movement of workstations into new segments is raising competitive pressures among the major players. "Apollo has been the dominant company in electronic and mechanical CAD, while Sun has led in software development and publishing," says Robert Herwick, senior analyst at Hambrecht & Quist (San Francisco). "But each has developed machines that encroach on the other's territory." Meanwhile, he says, Apple (Cupertino, Cal.) may position its enhanced Macintosh, now under development, as an alternative to Sun at the high end of the publishing sector, and DEC's workstation is building on the company's large installed base of minicomputers to take market share from everybody else.

In the wings is IBM (Milford, Conn.), which has already established itself in the workstation market with its AT, XT, and RT computers. But the AT and XT do not have the performance power of a Sun or an Apollo, according to Piper's Smaby, and the RT has been a disappointment at best because of its weak graphics and slow speed. "However," he says, "IBM is rumored to be developing a workstation based on the new Intel 386 chip, which would be a significant extension of its PC-based product line." Indeed, says Smaby, within five years DEC and IBM could control two-thirds of the market, with Sun and Apollo fighting it out for the rest. □ ***—Dennis Livingston***

that could easily lead to confusion because system commands often differ.

Now almost 20 years old in concept, UNIX has become a de facto standard for workstations and other engineering and scientific computers because it runs on a wide variety of machines and is available from many vendors. "There are so many good people with a vested interest in UNIX that if new features appear to be needed, the UNIX clan will add them to the operating system before work on a completely new system could get off the ground," says Sun Microsystems' Joy. Thus Joy, one of the prime architects of the original 4.2BSD UNIX, expects the operating system to remain the workstation standard "at least until 1990."

Despite his close attachment to UNIX, Joy admits that much of the criticism of the system is valid. For example, UNIX does not adequately support programs that handle network services or highly interactive programs where a number of small tasks need to be undertaken with close supervision. Sun and other vendors are working to improve such networking aspects of UNIX. Several vendors are working with AT&T Technologies (Morristown, N.J.) to achieve a single UNIX standard that will combine the features of AT&T's System V and the Berkeley 4.2BSD release. Such a "unified" UNIX will probably appear late this year and will go a long way toward ensuring the operating system's survival.

Although much application software already exists for workstations—all the manufacturers offer extensive catalogs of packages supplied by independent vendors—many programs are simply conversions of older packages designed for the Digital Equipment VAX or similar computers. Often written in Fortran, a scientific language whose roots go back more than 30 years, many programs fail to take advantage of the networking possibilities of a workstation environment. However, the widespread acceptance of UNIX has led to expanded use of C, a language first employed by the developers of UNIX to create parts of the operating system. Because much of the newer and more efficient workstation software is being written in C, and C is available on many systems, application software can be readily converted to run on a variety of workstations and other computers.

A new version of C, called C++, is coming along as a successor to C, says Joy, because it provides better structuring than the original language. Structured programs can be readily broken into blocks for group development or for revision, especially important for workstation software developers. For expert system programming, says Joy, Lisp is becoming widely used. "These high-level languages permit the writing of much more ambitious software that will make good use of very-high-performance workstations. Just imagine a spreadsheet with artificial intelligence that would allow a financial expert to use his intuition for a simulation." Such tools amplify human intelligence, says Lynn Conway, professor of computer science at the University of Michigan (Ann Arbor). "We will see the development of software tools for interacting so people can be more productive."

Ease of interaction is heavily dependent on the user interface and in particular on the windowing system used on workstation displays to observe several programs or processes that may be executed simultaneously. There is no agreement on a windowing standard, but Sun is pushing its Network-extensible Windowing System (NeWS) very heavily. However, Apollo, Digital Equipment, and Hewlett-Packard recently decided to support X Window, a package developed in the public domain as part of MIT's Athena project. IBM plans to include X Window in Andrew, an advanced distributed computing environment it is developing with Carnegie-Mellon University. Industry observers expect NeWS and X Window to coexist and, perhaps, to be offered together by some workstation makers, just as both versions of UNIX are offered today.



Multiwindow display on an Apollo workstation shows (clockwise from top left) a PC application (Lotus 1-2-3), a DEC VAX file, a technical publishing program, and an IBM mainframe graphics application.

Not only are workstations improving their performance to encroach on the turf now occupied by minicomputers and superminicomputers, but their costs are coming down to a price level—$15,000 or less—that is beginning to compete with the more expensive PCs. Indeed, Nelson expects costs to fall still further so that "a portable workstation costing around $1000 is a possibility by 1990." Such a workstation may be a step toward the ultimate PC: the hand-held "Dynabook," predicted by Apple Computer research fellow Alan Kay several years ago at Xerox's Palo Alto Research Center, where he was a key member of the workstation group. Through AI, the Dynabook would have features tailored to each user and would be as easy to use as a pencil and a notebook, says Kay.

Meanwhile, the personal computer makers are not exactly sitting still. Intel's 32-bit microprocessor chip, the 80386, is beginning to appear in a new generation of personal computers, notably the Compaq 386. Convergent Technologies (San Jose, Cal.) has announced an 80386-based workstation that will run UNIX and MS-DOS simultaneously, intended largely for sale to engineering OEMs rather than to end users. Although IBM has yet to announce an 80386 personal computer, such a system from the dominant force in the PC market could swamp the efforts of the workstation makers to move into lower-price markets. And Apple is reported to be readying a 68020-based 32-bit computer with color graphics that could compete directly—in both performance and price—with the least expensive workstations.

But at present, the 32-bit workstations have a considerable lead over the new 80386-based personal computers. Operating-system and application software exists in large quantity—whereas software for the 32-bit personal computers is lagging, largely because PC software developers are waiting for IBM to announce its machine and put its seal of approval on an operating system. In the meantime, Sun and Apollo have introduced low-cost workstations capable of running conventional IBM PC software.

In any case, the rapid adoption of networking and file standards by the workstation manufacturers will undoubtedly put them in a good position to install large networks of both PCs and workstations linked to existing corporate mainframe computers. Workstation makers clearly have a lead in the networking of computers, which should result in wider use of workstations outside scientific and engineering applications. In fact, it seems likely that the distinction between a PC and a personal workstation will essentially become unimportant in the not too distant future. More important, personal workstations will bring about what Conway at the University of Michigan terms group computing, where networking and distributed computing allow people to interact more extensively. □

Jeffrey Bairstow is a senior editor of HIGH TECHNOLOGY.

For further information see **RESOURCES**, *p. 64.*

MANAGING COMPUTER COMMUNICATIONS

As data networks grow more complex, companies are seeking better tools for spotting and correcting failures

BY DWIGHT B. DAVIS

Computer communications used to be simple. A company merely leased a few phone lines from AT&T, bought some modems from a vendor, and began sending data between its home office and remote sites. If service failed, it meant calls to the modem supplier or to Ma Bell.

Today, there's a whole new world of data communications, and a wide range of factors pushing corporations into the role of managing their own networks. There are many more service and equipment providers—including local phone companies, satellite suppliers, microwave vendors, local-area networking companies, and value-added network operators—and the networks are far more complex, often containing analog and digital links of all sorts as well as intermixed voice, data, and video traffic. The importance of the information traveling on these hybrid networks, moreover, has grown substantially. As a result, companies are scrambling to find ways to monitor and improve their networks' performance, to detect and prevent problems early on, and to recover rapidly when the inevitable failures occur.

It wasn't long ago that network management played a weak second fiddle to the network devices such as modems and multiplexers in companies' buying decisions. But "as the sophistication of the equipment hooked up to a network has increased, network management has gone from being a page-50 addendum in requests for bids on large networks, to being a page-one item," says Lou Krieg, development manager for wide-area network product operations at Codex (Canton, Mass.).

Products designed to assist network management range from simple self-diagnostic features packaged within each network device to full-blown command centers that attempt to provide a single point of control over the entire operation. Different products monitor different parameters and offer varying capabilities to take corrective action.

This proliferation is causing problems because the network management realm, like other areas of computer communications, lacks standards. As a result, networks that contain computer and communications products from a variety of vendors end up with a variety of incompatible network management systems. Typically, a large company's nationwide network may include a host-based management system that monitors the mainframe computer and the stations operating under its direct control, a modem management system designed to collect operational statistics from the network devices themselves, and various local-area network (LAN) management systems monitoring the devices and traffic on LANs at different sites around the nation.

All of these systems—and any others that exist on the network—operate under their own proprietary protocols and often involve one-of-a-kind procedures to run them. Aside from putting a strain on hard-to-find network operators, this diversity foils a company's attempts to cohesively monitor and control its entire network from a central command site. It would be difficult, if not impossible, for a central-site operator in, say, New York to work through the many layers of network management to determine that a terminal running on a LAN in San Francisco was malfunctioning. Correcting the problem from headquarters would be an even more daunting task.

The emergence of widely accepted network management standards would go a long way toward improving this situation. But while some movement in that direction has begun, few observers expect substantial progress anytime soon. In the meantime, a range of vendors are developing different schemes to provide the most comprehensive possible management of the hybrid networks.

Network management tasks. While vendor solutions to network management differ considerably, there is general agreement on the tasks such systems must address. The main categories of operation include network planning, collection and display (often through graphic representations of the network) of alarm signals from different communications



DANA SIGALL

BBN's James G. Herman notes that most networks grew without any guiding architecture, making them extremely difficult to manage comprehensively.

devices, tools to diagnose the problems, network control, and administrative tasks such as billing and cost allocation.

The parameters monitored by network management systems fall into two distinct categories: physical network statistics and logical network information. The communications device suppliers, including Codex, Infinet (North Andover, Mass.), Timeplex (Woodcliff Lake, N.J.), Case Communications (Columbia, Md.), Paradyne (Largo, Fla.), Infotron Systems (Cherry Hill, N.J.), General DataComm (Danbury, Conn.), and Racal-Milgo (Fort Lauderdale, Fla.), typically monitor the physical network—that is, the operation of the modems and multiplexers and the lines linking them. Most of these vendors perform such monitoring via a "secondary" communications channel, which uses a frequency different from that carrying the actual network traffic to transmit statistical information from the intelligent network devices to a central site.

Because these vendors are able to get into the guts of their proprietary equipment, they can often exert remote control over the devices as well. So a malfunctioning modem, for example, can be shut down, or a spare remote modem can be automatically called to set up a temporary dial-up link if a leased line fails. Most modem vendors can also support other suppliers' modems on their networks through a "wrap-around" facility that encapsulates the foreign devices. But they are unable to monitor or control such outside products as completely as their own.

Logical parameters have traditionally been addressed both by computer vendors, with management schemes tied to their proprietary network architectures, and by independent vendors, which sell management systems that overlay on networks containing a mix of different vendors' products. Independent suppliers like Avant-Garde (Mount Laurel, N.J.), Dynatech Packet Technology (Alexandria, Va.), and T-Bar (Wilton, Conn.) sell such products, which monitor the actual traffic flowing on the network, not the diagnostic signals sent from modems and multiplexers over a secondary channel. In essence, these are "performance measurement" systems, keeping tabs on user response times, the destination of data routed across the network, and other indicators of the network's level of service.

Because the physical and logical types of management systems measure different parameters, they can often coexist within the same network, performing their distinct functions side by side. But such an approach usually requires that the network operators buy two sets of

equipment and learn two different diagnostic procedures. Vendors have begun to realize that combining the functions within a single integrated system will give them a clear selling advantage. The communications device vendors, therefore, have started to add performance measurement options to their systems—although not all are completely integrated with their existing physical management products—and a few performance measurement suppliers are adding the capability to exert some level of control over the network devices.

Suppliers hope ultimately to allow a network operator to use a single workstation for viewing an entire network's operations. Three basic strategies to achieve this goal have emerged. The first, commonly associated with the modem and multiplexer vendors, is to get customers to buy all their communications products from one manufacturer. In the resulting homogeneous networks, the single vendor is able to offer comprehensive management and control facilities linked to its products.

A second approach is based on the assumption that many networks will continue to contain various products and protocols, and attempts to provide a common point of management over all of them. Vendors pursuing this strategy typically provide a single, centralized workstation to emulate the management schemes used by different segments of the network. Operators must still know how to run each management scheme, but they can do it from a common terminal.

The third approach is being pursued by IBM (Rye Brook, N.Y.) alone. The company has published its proprietary network management protocols so that other suppliers can build interfaces between their products and the IBM communications world. If enough suppliers acquiesce to IBM's standard, a wide mix of products could be linked under a single network management environment.

One-stop shopping. The traditional communications vendors realized some time ago that network management represented more than just a market in and of itself. If a customer buys a management system that works only with the same vendor's modems and multiplexers, the customer will keep buying equipment from that supplier as the network grows.

The trouble is, though, that very few existing large networks are based on equipment from just one supplier. "Most company networks have tended to grow through a series of isolated decisions," says James G. Herman, director of telecommunications consulting at BBN Communications (Cambridge, Mass.). "As a result, they had no overriding architecture guiding them as to what kinds of devices they should use."

The modem/multiplexer vendors are therefore at their strongest selling position if they can get into a network at ground zero, before it has had a chance to evolve in 10 different directions. But even if a company chooses to go with a single supplier from the start, problems can develop. No single vendor has a product line broad enough to satisfy every networking need of every customer. At some point, customers may be forced to buy equipment from other suppliers, and these devices may not fit easily into the existing network management scheme.

Often, in fact, even devices sold by the original vendor may not fit into the management scheme. For example, Infinet sells a line of multiplexers that operate on high-speed "T-1" lines, but these products don't yet fall under the purview of the firm's Series 90 Network Information System. Integrating the T-1 multiplexers with the Series 90 "is on our list of things to do next," says Bebe Jordan, Infinet's manager of applications software development, but the current incompatibility is indicative of how hard it is to achieve total network management, even within a single vendor's product line. She notes, however, that Infinet has already made progress on other integration fronts. For example, says Jordan, its PMS-III performance measurement module is compatible with its overall network management scheme, while the performance measurement products sold by competitors must still operate independently in a standalone mode.

Despite such limitations, the modem/multiplexer suppliers have the strong selling point of being able to get extremely detailed operational statistics from the devices that do fall under their network management umbrella. With access to statistics on important parameters such as signal-to-noise ratio and received signal strength, users are often able to pinpoint and define a problem. Just as important, these management systems usually provide the capability to take corrective action.

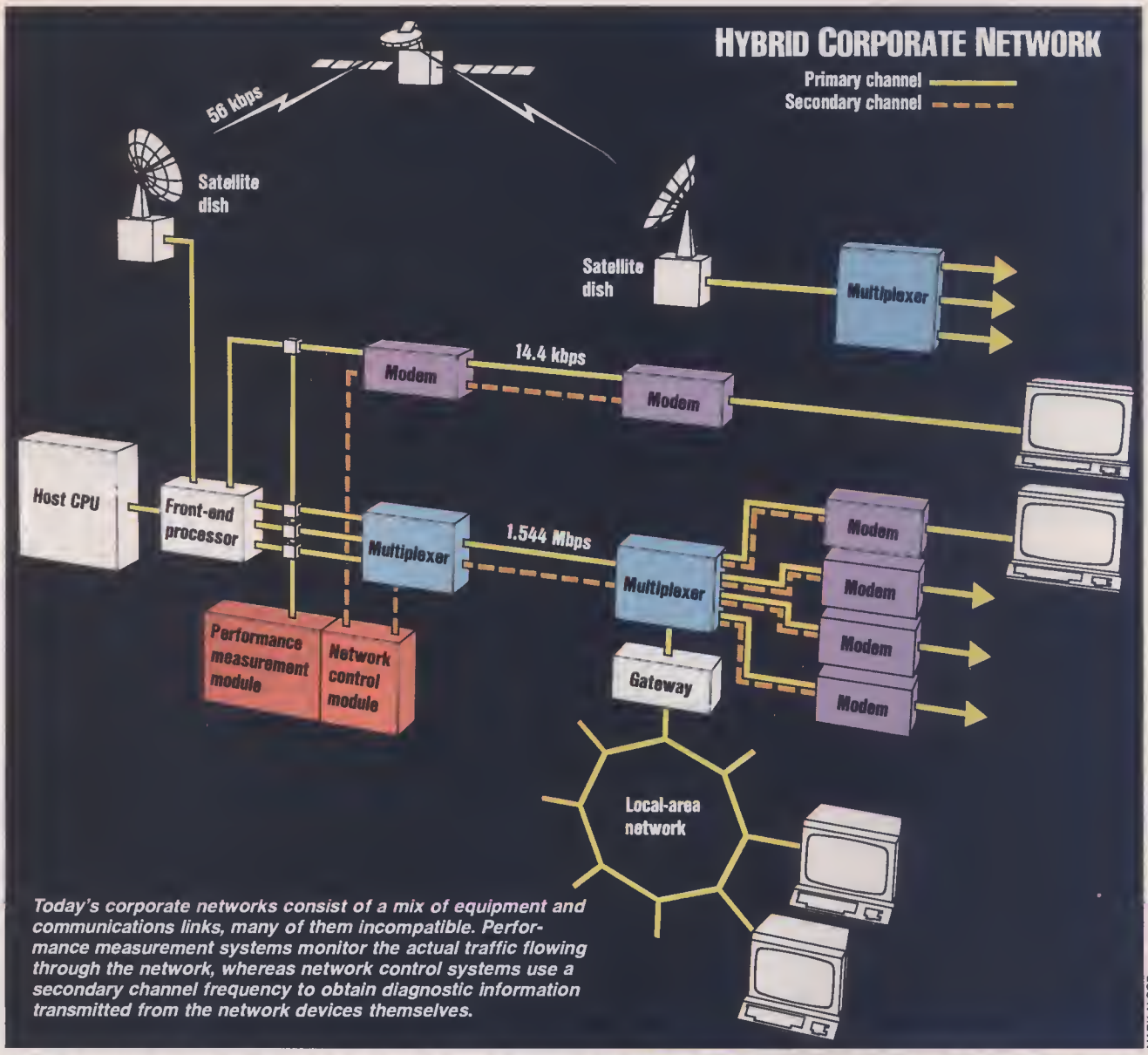
Monitoring mixed nets. Independent suppliers of network management systems may not yet have the ability to control network devices as completely as the device vendors, but they can claim a wider scope of operation. Also, these suppliers cannot be accused of having an ulterior motive for selling management systems—such as selling modems and multiplexers—since network management is often their one and only business. And their strategy of supporting a variety of equipment in each network meshes nicely with existing installations, in which multivendor operations are the norm, not the exception.

Given that most of these independent vendors first made their mark in the business by providing performance measurement tools, monitoring the actual network traffic remains their flagship capability. But because network data often derive from many different systems and are thus formatted in many different ways, performance measurement systems must be able to decipher each relevant protocol in order to extract information such as a particular terminal's activity level. A key selling point of such systems, therefore, is how many of the major protocols they can interpret. Avant-Garde's Net/Alert system, for example, supports more than 50, including IBM Bisync, SNA/SDLC, Honeywell VIP, HP 2645 Bisync, NCR Comten CNS, Burroughs Poll-Select, and X.25.

As the modem/multiplexer suppliers have moved into performance measurement territory, the independent suppliers have realized that they, in turn, must expand into device monitoring and control. Their strategy here, as always, is to support as many products as possible in an integrated fashion. With such breadth, the vendors reason, they can effectively compete with the device suppliers' network management systems, which offer capability for control within a much more restricted universe.

Avant-Garde's entry in this area—the Net/Command system—works by emulating on a single workstation the network management schemes of the device vendors represented in any given network. If a corporate network has IBM, Codex, and Timeplex equipment, each with its own network management system, Net/Command collects and consolidates the alerts from each of these systems. Custom interfaces must sometimes be built to emulate less common management systems, and operators must still learn a variety of different management procedures. But Net/Command can integrate the alerts. For example, says director of marketing Barbara Noti, it can recognize that alerts from two different network management systems are referring to the same problem. Without such centralization, network operators must assimilate and interpret these data using different workstation monitors, which can be an overwhelming task on large heterogeneous networks.

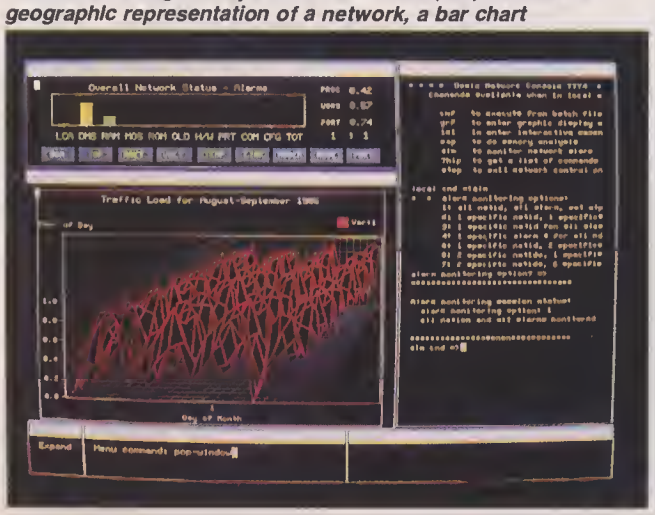
Doing things the IBM way. While both the device vendors' and the independent suppliers' approaches to network management have their advantages, neither yet provides total integration, under which a user at a single workstation employing a single

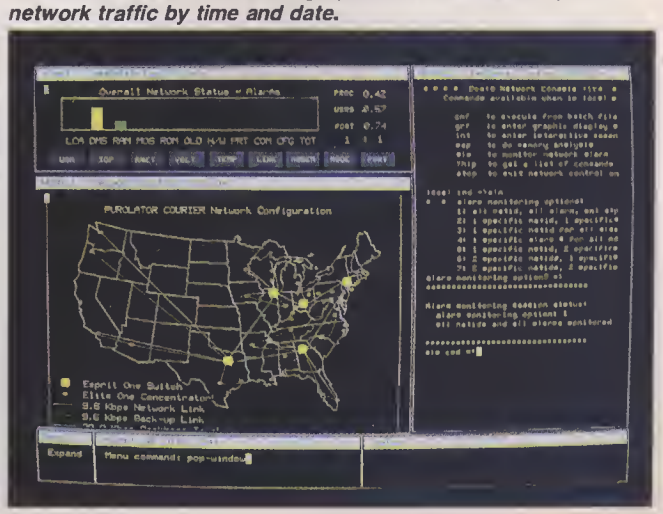


Today's corporate networks consist of a mix of equipment and communications links, many of them incompatible. Performance measurement systems monitor the actual traffic flowing through the network, whereas network control systems use a secondary channel frequency to obtain diagnostic information transmitted from the network devices themselves.

MARK ALSOP

Vendors employ sophisticated graphics to help operators diagnose network problems, as illustrated by these screens from Doelz's Engarde system. One screen (left) includes a geographic representation of a network, a bar chart indicating the number and types of alarms that have occurred, and a text window that gives details on the alarms. The other screen shows how 3-D graphics can be used to plot network traffic by time and date.



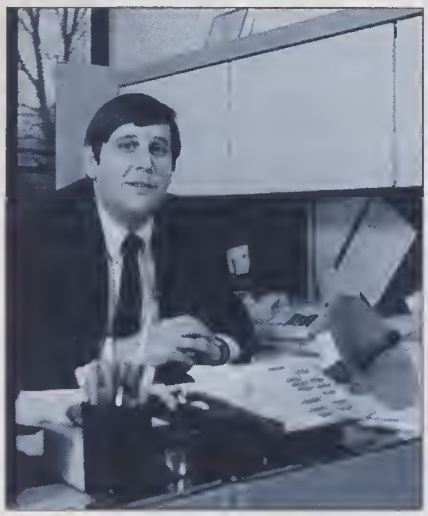


NETWORK MANAGEMENT: DISTINCTIONS BLUR BETWEEN TWO APPROACHES

Network management systems—which allow trained personnel to monitor performance of computer communications networks, to identify problems as they develop, and to take remedial action—currently make up a market worth some $87 million, according to Katherine Korostoff, senior market analyst at International Data Corp. (IDC) in Framingham, Mass. Revenues should increase to $194 million by 1989, she estimates, with substantial growth continuing through the 1990s.

The present market consists of two segments. The largest so far, totaling $60 million, comprises devices that monitor and correct the functioning of modems, multiplexers, and other network components; such products are usually built into the hardware they monitor. Market leaders, based on shipments in 1986, are Codex (Canton, Mass.), Paradyne (Largo, Fla.), Racal-Milgo (Fort Lauderdale, Fla.), General Datacomm (Middlebury, Conn.), and AT&T (Parsippany, N.J.). Performance management systems—the other segment—monitor the operation of the entire network rather than individual pieces of hardware. They indicate, for example, where data are going, how long they take to get there, and where problems are developing. Two companies—Avant-Garde (Mount Laurel, N.J.) and Tesdata Systems (Herndon, Va.)—have a combined share of well over 50% of this $27 million market segment. None of the other firms in this segment, including Ocean Data Systems (Rockville, Md.) and Dynatech Packet Technology (Alexandria, Va.), have more than a 5% market share.

The distinction between monitoring individual devices and monitoring overall network performance is beginning to break down in response to customer demand for unified network management systems. For the hardware companies, this means incorporating performance monitoring capabilities into their products. Since each firm uses its own system, which is usually incompatible with the others, such a strategy can be used to convince network builders to buy as much of their hardware as possible from a single supplier. "Network management is not sold by these firms for its own sake, but as a means of promoting the equipment that works with it," says Joaquin Gonzalez, service director of enterprise networking strategies at the Gartner Group (Stamford, Conn.).



"Any modems, multiplexers, or other wide-area data network products currently brought to market must be able to carry out network management functions. End users want to do more with their hardware than just send out beeps."
Joaquin Gonzalez, Service Director
Enterprise Networking Strategies
Gartner Group

At the same time, the performance monitoring companies are working on software that integrates data from their systems with status information from specific devices. But many of these firms lack the financial resources and marketing clout to compete with the hardware vendors, according to IDC's Korostoff. She suggests that they are likely to end up establishing agreements whereby a hardware vendor will integrate performance monitoring products into its equipment.

While each sector moves in the direction of the other, IBM (Rye Brook, N.Y.) has extended information monitoring and control to encompass a variety of interlinked voice and data networks, including local-area networks, dedicated high-speed telephone lines, PBXs, and IBM's own computer networking system. No modem manufacturer or performance monitoring firm has gone this far with an existing product. "A lot of people in automotive, financial-services, and other major industries are now putting together such hybrid networks," says George Newman, an analyst at IDC, "and they're looking for ways to connect all this diverse equipment into some sort of cohesive system." IBM's product has come along at just the right time to fulfill this need, he believes, although it will have to integrate its system with current network management systems. To accomplish this, IBM has published the protocols for its product so that other suppliers can create appropriate interfaces.

Controlling 85% of the mainframe market—the environment in which most networking is done—IBM is in a unique position to impose its standard on the industry. "IBM's efforts could make a lot of companies' network management products vestigial, if not obsolete," says Eric Arnum, editor of *Telecom/IBM*, a newsletter published by International Resource Development (Norwalk, Conn.). "These people are either going to have to adapt their products to the IBM standard or get out of the network management business." □ ***—G. Berton Latamore***

JIM BROWN

user interface could monitor and control an entire heterogeneous network. It still remains for one type of supplier or the other to develop an extremely powerful and intelligent central-site system that collects all available network management information, merges it, and conveniently presents it to a single operator. Meanwhile, IBM is taking an approach that is much simpler (technically, though not politically). It is trying to get every vendor to adhere to a common network management standard.

IBM dominates the corporate computing field, and the company's Systems Network Architecture (SNA) is the most widely used proprietary networking scheme. However, a variety of incompatible network management functions are embedded in SNA. In May 1986, IBM moved to consolidate many of them under a common network management scheme called Netview. Then, later in the year, the company introduced Netview/PC, a product designed to help other communications vendors design interfaces that make their products compatible with the Netview protocols. Unlike most network management systems, which deal only with data communications, the Netview/PC product is also able to support voice communications products such as private branch exchanges.



WARREN UZZLE

IBM's Bill Warner notes that because network management is labor-intensive, a major goal is to automate as much of the process as possible.



CAROL LEE

Along with their monitoring and analysis roles, systems must also give network operators the tools to respond to problems, says Infinet's Bebe Jordan.

Some communications vendors have already indicated their willingness to connect to the Netview environment. Timeplex, for instance, offers a product called Link/View that connects one of its proprietary network management systems to Netview, and has indicated that it plans to provide similar interfaces for the rest of its product line. "By providing a series of compatible interfaces to Netview," says Harry Thomas, VP of marketing, "the company recognizes the importance of IBM's efforts to centralize alarm reporting of all components of an integrated network."

Other vendors are not yet convinced. Some, such as Codex, question whether Netview is powerful enough to manage the complex networks common today. "The Netview/PC approach is really suited to bringing small, specific subnetworks under the control of Netview," says Codex's Krieg. "Trying to bring a very large network with everything from high-speed circuits to local networking links under the control of Netview would be a pretty daunting task."

Infinet's Jordan agrees, and also questions the willingness of companies to acquiesce to the IBM standard. "I don't believe that the modem vendors, the switch vendors, the multiplexer vendors, and so on are going to change the protocols they have been working on for 10 to 15 years," she says. Still, she admits, "IBM is the only one with the potential to implement such a standard."

For its part, IBM claims simply to be responding to its users' needs. "We're trying to help our customers manage mixed-environment networks by helping them reduce costs, especially the costs associated with the network personnel," says Bill Warner, director of business systems management at IBM's Communications Programming Laboratory (Raleigh, N.C.).

Wariness on the part of its competitors isn't the only obstacle IBM must overcome in its attempt to establish Netview as a standard. "Working against the IBM trend is a current effort to produce international network management standards," notes BBN's Herman. He points to work associated with a widely accepted networking paradigm called the Open Systems Interconnection (OSI) model, which sets up standard levels of communications protocols but says nothing about how to manage a network. To remedy this shortcoming, the International Standards Organization is developing what it calls the OSI management framework, which Herman says is "like scaffolding erected around the basic OSI model." To effect monitoring and control, Herman explains, each of the seven layers in the OSI model incorporates a mechanism called a layer



CAROL LEE

Expert systems will incorporate not only vendor information about equipment characteristics, says Codex's Lou Krieg, but also operational data from users.

manager, which performs all the management functions for its layer and communicates with the top-most level of the model, the applications layer. Embedded in this layer is a specialized protocol that administers the activity of the lower layer managers and enables communication with other OSI networks.

Future trends. In the absence of one, universally agreed-upon approach, each vendor is trying in its own way to provide as much integration as possible, while at the same time adding capabilities to its network management scheme. Doelz Networks (Irvine, Cal.), for example, employs an unusual technique to deal with mixed communications protocols on a network. Instead of interpreting the protocols, the Doelz communications products encapsulate them with the company's own proprietary protocol. This process essentially masks the underlying protocols and permits them to be intermixed freely on the network. "We let different communications applications in a company share the same expensive line facilities, and provide them with a common network management scheme so that one team of people can troubleshoot IBM problems, Burroughs problems, or whatever," says Brian Dietz, Doelz's manager of high-level network management.

Another area of development—one being pursued by most network management vendors—is automation of monitoring and control tasks. "The biggest problem now is that most network management systems are basically manual," says Herman at BBN. "They feed people raw data, and the people must then manually go through relatively complicated fault-isolation procedures to fix things."

To increase automation will require that the network management systems diagnose problems and take corrective action themselves. As a result, many vendors are turning to artificial intelligence. Some have already developed expert systems that can assist operators in specific network management tasks. Case Communications, for example, offers the 5010ES-DCX, an expert system designed to help companies configure networks based on Case's DCX communications processors. "The user defines the services planned for the network, and the expert system then determines the best configurations for supporting those services," explains Art Alberding, senior director of product marketing.

Other companies are using expert systems to attack other pieces of the network



Avant-Garde's Barbara Noti says the firm's Net/Advisor expert system can assist operators by recommending steps for fixing network problems.

management puzzle. Avant-Garde sells a product called Net/Advisor that takes the information collected by its Net/Command monitoring product and helps operators analyze any problems. IBM also has AI projects under way in network management, says Warner, who adds that "the next step is to use expert systems technology to have the network system perform more of the tasks that now must be handled by operations personnel."

Warner cautions that the move to incorporate AI techniques in network management "is much more easily talked about than it is to achieve," and Codex's Krieg says it "will be a long, continuous process as the sophistication of the systems improves." But eventually, AI systems will offer the important capability of being able to incorporate information both from the network users and from the system suppliers. "Rule-based expert systems," says Krieg, "will ultimately allow an integration of user preferences—based on their operating experience and individual approaches—along with the supplier's knowledge base of its products and how best to diagnose them."

Even with the aid of technologies such as artificial intelligence, however, the fundamental problem of integrating products from different vendors will not disappear overnight. The adoption of the OSI management framework standards will help, but these are not yet fully defined, and BBN's Herman estimates that they won't be ratified for at least two or three years. Once these international standards are available, "there is good reason to believe that they will become a major market force," Krieg predicts, although he adds that IBM's SNA protocols will continue to remain widespread even with the advent of the OSI management framework.

Most industry participants agree that IBM's market dominance gives the company as good a chance as any to impose some measure of standardization and integration on the network management field. This is especially true when it comes to monitoring the actual network traffic. "IBM already has fairly good command over the logical network," says Herman, "and it will remain the leader in this area for quite a while."

But most agree that even IBM will have difficulty in integrating the various network management schemes tied to specific brands of network devices, despite its push to establish the Netview protocols as standards. Companies running large IBM networks today typically incorporate modem management systems from vendors such as Codex and Infinet as well, says Herman, and he sees no indication that this situation will quickly change. "Netview is a great marketing ploy," he says, "but I don't view it as a real breakthrough in terms of consolidating network management capabilities." As a result, he says, "customers will have to resign themselves to having some collection of physical network management schemes for a long time to come."

To minimize such incompatibility, Herman recommends that users carefully evaluate network management issues as they build new networks or modify existing ones. Companies tend to pick architectures for a variety of other reasons, including performance requirements, demographic issues, and economic considerations. "Network management," he says, "should be an important determinant, not just an afterthought." □

Dwight B. Davis is a senior editor of HIGH TECHNOLOGY.

For further information see **RESOURCES**, *p. 64.*

THE PENTAGON'S WAR ON COSTS

Armed with innovative procurement programs, the military is boosting industry productivity and competition

BY PETER GWYNNE



JULIE HOUCK

The Pentagon's procurement methods don't always result in $7600 coffee pots and $600 toilet seats. In recent years, Defense Department planners have been recognizing the need to improve their purchasing practices—a need given new urgency now that half a decade of rapidly increasing defense expenditure appears to be ending.

While saving money is the major goal, the new approaches offer other potential advantages. Military administrators anticipate that they will also help improve the quality of military hardware and software, and reduce the length of the acquisition cycle, which now averages 13 years from initial concept to delivery of production equipment. Planners also hope that fresh ways of ordering systems and parts will boost the quality of the nation's civilian technology.

Two programs—Get PRICE and Competition Advocacy—exemplify the new DOD attitude toward contracting. While still in relatively early stages, they are claimed to have already improved the efficiency of military acquisition and to have saved significant amounts of taxpayers' money.

Above: The Get PRICE program offers companies the chance to share in the savings made possible by modernizing manufacturing technology, says John Orphanos, of the Air Force's Electronic Systems Division.

GET PRICE. The Get PRICE program, started by the Air Force's Electronic Systems Division (ESD) at Hanscom Air Force Base in Massachusetts, is designed to motivate defense contractors to invest in modern, cost-effective manufacturing equipment for which they would not normally have the necessary capital. The incentive is a specified share of the overall savings that are realized by such investments.

The inspiration for Get PRICE (an acronym that ESD has reverse-engineered to mean Get Productivity Realized through Incentivizing Contractor Efficiency) was an early-1970s cost-saving program. Using $25 million in government funds, the Air Force identified a series of possible cost-reduction opportunities at a General Dynamics plant in Fort Worth that built the F-16 fighter. General Dynamics kicked in $100 million to carry out the innovations. The end result was that each F-16 cost $300 million less than before—with the savings shared by General Dynamics and the Air Force.

ESD has broadened the approach to cover plants that serve different government departments with a variety of products. In effect, the program is a business deal that establishes the ground rules under which the government and a contractor agree to share the savings that result from their joint investment in modernized manufacturing facilities. Three fundamental principles underlie each Get PRICE contract: both the government and the contractor must agree that their capital investment will improve factory operations and lead to lower prices for the government; incentive payments can only come out of the negotiated price reduction; and the agreement is not necessarily limited to a specific time period or government program.

The process starts when the contractor presents proposals to improve capital equipment in order to increase the productivity and cut the costs of a contract that the firm has already received. According to John A. Orphanos, deputy for acquisition logistics & technical operations at ESD, such proposals can benefit from extras not specified in the original request for proposals—such as offering more than minimum specifications, providing rigorous design and reliability testing, and giving ironclad guarantees. If a government review board approves the measures, the contractor and ESD negotiate the incentives—a flat dollar amount up to a specified maximum, based loosely on an agreed rate of return on the contractor's investment—that the contractor will be eligible to earn over a period that can extend to several years.

The wide-ranging benefits of Get PRICE are illustrated by the program's guinea pig. In 1980, Westinghouse's Defense and Electronic System Center (Baltimore) was undertaking 20 different Defense Department contracts for all three services in a single facility. In its proposals for a contract, the company emphasized generic improvements in its factory operations that could apply to all of its Defense Department work.

The actual Westinghouse program, started in 1983, focused on three work centers for avionics systems: SEAS (Standard Electronic Assembly System), REACH (Robot-Enabled Assembly of Cables and Harnesses), and MARK (Material Accountability and Robotic Kitting). The initial phase of the effort also led to a new electronic assembly plant in College Station, Tex.—probably the most modern printed circuit factory in the U.S.—built entirely with Westinghouse funds; the second phase, now under way with an Air Force contribution of $6.9 million in seed money, plans to use the technology for production in such programs as the radars for the F-16 and E-3A planes, and the ALQ-131 electronic countermeasures pod.

Initial results of the program show high promise. Savings have totaled more than $50 million, and Westinghouse has received almost all its initial incentive payment of $22 million. In addition, says Gerald Zahn, director of technology modernization and industrial management at ESD, "we have seen the quality of the product improve substantially." Before the program started, only 30–35% of the circuit boards prepared manually had no faults. Now, reports Zahn, about 90% come off the automated assembly line at College Station in perfect condition. According to Bernard Lavoie, ESD's director of manufacturing, the efficiency of the factory is already double that of the average U.S. assembly plant, and is approaching the efficiency of the most advanced Japanese plants.

The Get PRICE program has already saved the Air Force more than it has paid out in seed money.

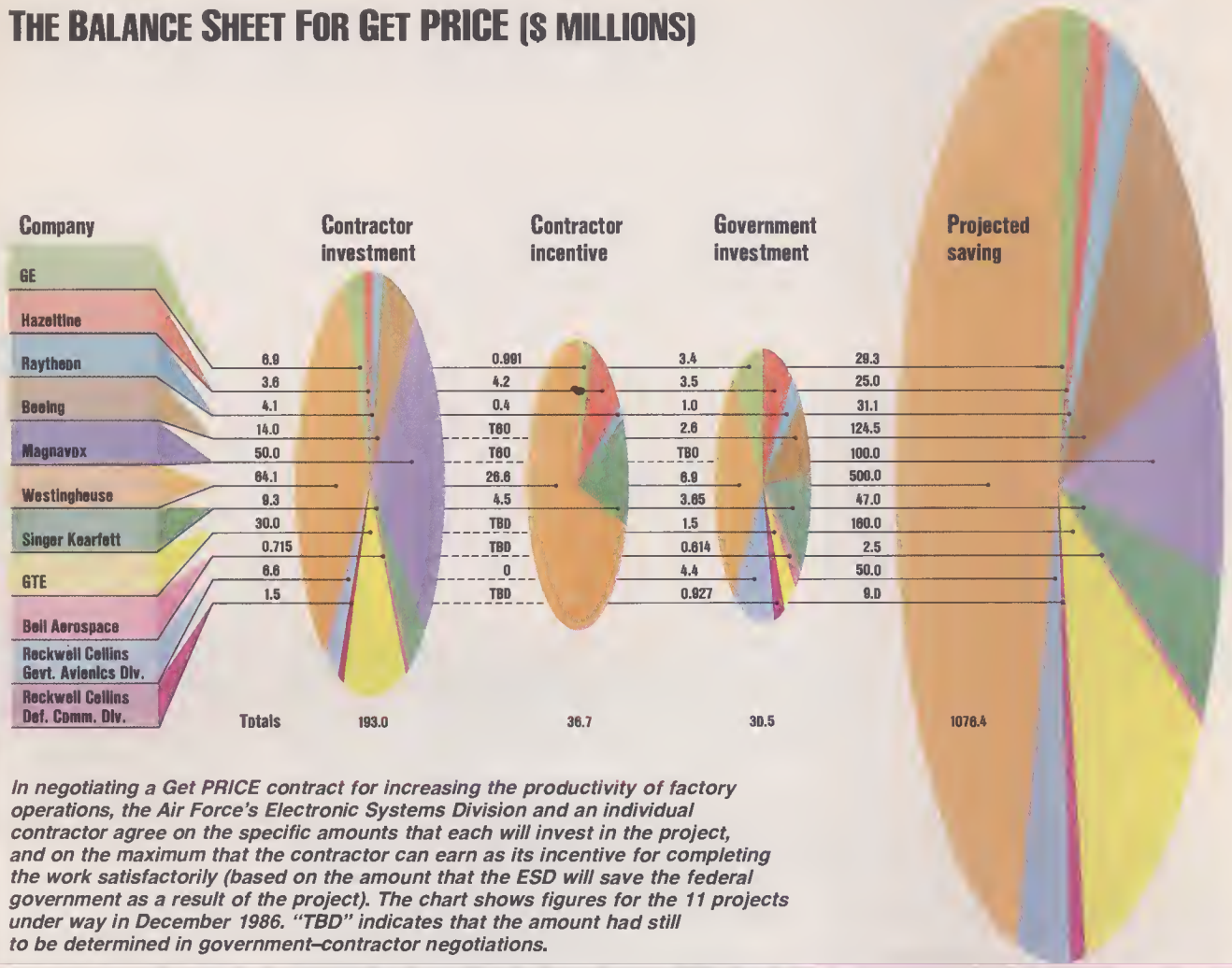
Other Get PRICE programs span a wide range of contractors and capabilities. General Electric (Syracuse) has built a new machining center for its Seek Igloo, North Warning, and Peace Shield ground-based radar programs. Rockwell International's Collins Government Avionics Division (Cedar Rapids, Ia.) has created an integrated chip assembly system and robot-assisted mechanical preparation, both of which automate electronic assembly operations that were previously labor-intensive. Collins has also developed new systems to enhance quality control and improve integration of design and manufacturing data for the Navstar Global Positioning System and for the Air Force's JTIDS (Joint Tactical Information Distribution System) Class II ground-to-aircraft datalink terminal program. Hazeltine Corp. (Greenlawn, N.Y.) and Singer's Kearfott Division (Little Falls, N.J.) have also modernized work centers that mainly benefit the JTIDS program. GTE's Government Systems Corporation (Needham, Mass.), Raytheon's Equipment Manufacturing Division (Waltham, Mass.), Magnavox (Fort Wayne, Ind.), Bell Aerospace (Buffalo, N.Y.), and Boeing (Seattle) have also started Get PRICE programs.

Get PRICE has already moved into the black: the $30.5 million of seed money advanced by ESD for projects by 11 contractors has been exceeded by the $37.3 million in savings that ESD has earned from the projects run by Westinghouse and General Electric alone, and the Air Force regards that as just a sampler. By 1991, it estimates, the program will have yielded a total savings of about $1.1 billion, based on cost comparisons of manufacturing in the Get PRICE plants before and after the modernization that the program provides. Meanwhile, the companies in the program have spent close to $200 million on new manufacturing technology that they probably would not otherwise have purchased.

The initial participants in the program were prime contractors who signed their agreements directly with ESD. The division has now taken the next step—putting a prime contractor in charge of a Get PRICE program that will encourage its subcontractors to share in savings made possible by investing capital to modernize their facilities. A new office at the Grumman plant in Melbourne, Fla., which manufactures components of the Joint STARS radar system, will work on its own Get PRICE agreements with about a dozen of its subcontractors.

Get PRICE is also encouraging new forms of technology transfer among defense contractors. Because the technologies encouraged by the program are generic, they can be readily adapted to defense plants other than those for which they were originally designed. That gives Get PRICE contractors the opportunity to do business with other defense companies. Westinghouse, for example, has recently agreed to adapt its smart manufacturing technology for the electronic assembly of the MX missile system being

THE BALANCE SHEET FOR GET PRICE ($ MILLIONS)



In negotiating a Get PRICE contract for increasing the productivity of factory operations, the Air Force's Electronic Systems Division and an individual contractor agree on the specific amounts that each will invest in the project, and on the maximum that the contractor can earn as its incentive for completing the work satisfactorily (based on the amount that the ESD will save the federal government as a result of the project). The chart shows figures for the 11 projects under way in December 1986. "TBD" indicates that the amount had still to be determined in government–contractor negotiations.

CHART BY DAVE HANNUM

undertaken by Rockwell International (Anaheim, Cal.); it is also working on a circuit card assembly processing system for a Navy-funded program under development by IBM (Oswego, N.Y.).

Thomas Murrin, president of Westinghouse's energy and advanced technology group, sees this type of technology transfer as one of the program's major contributions to enhancing American industry's global competitiveness. "The cooperation that comes from working more closely with American contractors, even though they are at times our competitors, will enable us to do what the Japanese have been doing magnificently throughout their industry for 20–30 years: competing and cooperating at the same time."

The program did not initially receive universal acclaim. From the start, critics in the Air Force, Congress, and industry have expressed two major concerns. One is that Get PRICE encourages too much cozying up between the government and its contractors. But much of that concern has abated, because of the positive results realized so far. "The fact that, unlike the situation in most defense contracts, both government and contractors must put up capital for Get PRICE programs," says Lavoie, "means that both are more willing to cooperate on improving efficiency, and hence guaranteeing returns on their investments."

Another significant worry is that the accounting systems traditionally used to figure costs in military contracts seem unable to quantify fully the savings that Get PRICE ostensibly generates. Observers basically agree that the cause of the problem is the accounting methods' unsuitability to today's contracting arrangements rather than the lack of significant savings. The difficulty of detecting the savings, however, has led groups in the military and contractor sectors to seriously study new accounting methods.



M. C. VALADA

Anthony DeLuca, the "competition advocate" at Air Force Systems Command, has doubled the percentage of AFSC contracts awarded competitively.

COMPETITION ADVOCACY. For years, the sole-source contract, renewed annually, was a staple of defense procurement. But on April 1, 1985, the Competition in Contracting Act became law. Under its terms, "competition advocates" in each branch of the service must ensure that, wherever possible, bids on contracts for Defense Department work should be competitive. The job is not a passive one; competition advocates are charged with actively arranging for competition among defense firms for contracts that do not initially draw more than a single bid.

Two years after the act became law, the concept of Competition Advocacy, pioneered by Navy Secretary John Lehman, has become part of the services' infrastructure. The Navy now has 74 competition advocates, the Air Force 63, the Army 26, and the Defense Logistics Agency 15.

The initiative plainly represents a political response to public perceptions about the Defense Department's procurement practices. "We have been in a defensive crouch on hammers, toilet seats, and coffee makers, and breaking down the barriers to competition comes to grips with that," says Thomas E. Cooper, Air Force assistant secretary for research, development and logistics.

Such advocacy is producing positive results in terms of both lowered costs and the creation of a larger industrial base for any specific kind of military system. According to Lehman, strong competitive pressure reduced the cost of the McDonnell Douglas F/A-18 from $22.5 million in 1982 to $18.7 million three years later. Similar savings were recorded for the Navy's Grumman F-14A, A-6E, and Lockheed P-3C programs. In one spectacular example, a contractor asked for $6 million to develop a missile system for the Air Force's Electronic Systems Division, and turned down ESD's counteroffer of $4 million. So ESD set up a competition for the production—and awarded the contract for just $1.5 million. In another example, the price paid by the Air Force Logistics Command (Wright-Patterson Air Force Base, Ohio) for outer wing-tip skins for its F-4 fighter dropped from $2066 to $194 apiece.

Sparking fresh competition among contractors who have invested huge amounts of capital in large military programs is not easy. The military business, after all, is a seller's market; whereas companies in the civilian sector must seek out or create a demand for their products, the armed services have an obligation to buy products, and hence must seek out companies that will sell to them. So traditionally, the competition for military contracts has occurred only in the earliest stages, before the individual service makes its initial choice of contractor. Once that first contract is awarded, the recipient tends to be favored, and rival companies are leery of competing for follow-up work. "We've found in the past that when a sources-sought synopsis was issued where we've previously had a single source, other potential competitors tended to shy away," says Anthony J. DeLuca, competition advocate at Air Force Systems Command (Andrews Air Force Base, Md.).

One way of breaking this cycle is to aggressively solicit companies that would be unlikely to compete without encouragement. By alerting contractors and subcontractors to forthcoming projects, for example, the services stimulate new competition. In one notable case, the Air Force persuaded Raytheon to compete with General Electric to build west- and south-facing units for a network of over-the-horizon radars that will detect enemy bombers and cruise missiles, even though GE developed and built the initial east-facing unit (HIGH TECHNOLOGY, Nov. 1986, p. 46).

In addition to reducing costs, Competition Advocacy is creating a larger industrial base for military systems.

Another tactic is to encourage contractors to form teams to bid for new contracts. Once the winning team's development work is completed, team members become independent contractors again, competing among themselves for shares of the production contract. The Navy and Air Force have specified this form of competition for the Integrated Electronic Warfare System—the self-protection system, expected to cost more than $2 million per aircraft, that will be installed on the Advanced Technlogy Fighter and the Advanced Tactical Aircraft (HIGH TECHNOLOGY, Aug. 1986, p. 56).

An even more direct approach is known as the leader–follower dual source. The leader is the major designer and builder of a new system—the company that formerly would have been the sole prime contractor. The follower is a company brought in by the military to share the technology, learn the specifics of the business, and bid against the leader for future business. The Air Force called for such a relationship in the contract for the AMRAAM missile, in which Hughes Aircraft (Canoga Park, Cal.) is the leader and Raytheon (Bedford, Mass.) the follower, and in the MILSTAR radar system, in which Raytheon, Rockwell International (Santa Ana, Cal.), and Bell Aerospace Textron (Niagara Falls, N.Y.) alternate as leaders and followers on specific components.

Competition advocates have shown some impressive results. In fiscal 1986, for example, Air Force Systems Command awarded 49.4% of its contracts competitively, up from just 26% two years earlier. For Defense Department contracts as a whole, the dollar volume of contracts awarded competitively has increased from about 35% in 1984 to almost 50% this fiscal year.

But competition does not always meet the mandate of improving the quality and cost of equipment acquired by the military. "You need to avoid myopic aggressiveness," says DeLuca, because some programs would not benefit from competition. He cites as an example the $40 million B-1B bomber: "If we tried to set up a second supplier, the cost would be more than any realized savings from that leader–follower competition." The Air Force learned that lesson when it tried to set up Teledyne (Los Angeles) in competition with Williams International (Walled Lake, Mich.) to build engines for cruise missiles. The cost of the competitive engines came in at almost double the Williams cost of $176,000 per engine. In both cases, the size and complexity of the program reduce the chances that a competitor starting from scratch will be able to realize savings.

Predictably, the services' enthusiasm for induced competition is not entirely shared by industry. Prime contractors, in particular, worry that subcontractors who win through forced competition may not be as sophisticated in technology and quality control as the incumbents that they replace. The result could be a reduction in the quality of the prime contractors' products. Contractors also complain that Competition Advocacy forces them to undercut themselves by releasing to potential competitors technical details that they regard as proprietary.

Nevertheless, the services argue that competition is here to stay—that while supporting an infrastructure of Competition Advocacy costs money, it also yields results. First, the Department of Defense estimates that competed contracts save about 10% over sole-sourced contracts. There's also the belief that defense companies tend to improve their efficiency with the mere mention of the possibility of competition. Finally, the need to invoke appropriate competitive bids for major contracts and subcontracts has forced the services to examine their own specifications and procedures more thoroughly than before, an exercise that has itself resulted in greater efficiency and savings across the military spectrum.

COMPETITION: THE CASE OF THE ATF

The Air Force expects to save time and money by emphasizing competition in development of the Advanced Technology Fighter (ATF), the new aircraft designed to ensure U.S. air superiority and scheduled to begin service in the mid-1990s. Under traditional practice, the Air Force would have selected three individual airframe contractors last October for the project's demonstration and validation phase. Competition would have ended after a year, with the Air Force selecting a single contractor to develop the prototype ATF airframe and eventually to manufacture it. That schedule would have produced an operational craft in 1997.

Under the new rules, the Air Force will maintain competition throughout the process—ironically, by encouraging teamwork at the beginning. It urged the seven contractors submitting bids to form teams, and awarded demonstration and validation contracts to the two groups that did so: Northrop Corp. in alliance with McDonnell Douglas, and the trio of Lockheed, General Dynamics, and Boeing Military Airplane.

The two groups are encouraged to complete their contracts—and the follow-up work leading to prototype airframes—as fast as possible. The date of completion will be one factor in the selection, scheduled for 1991, of the team that will build the plane. The winning team will be expected to produce an operational ATF by 1995, at which point its members will separate to compete with each other for shares of the new production contract.

OTHER PROGRAMS. A variety of other projects also designed to control costs by increasing efficiency are now in their early stages. They include "early prototyping" and "readiness improvements through systems engineering" (known as RISE 2000).

The effective development of new technology into usable military vehicles, weapons, and manufacturing systems has often been doomed by the Pentagon's failure to check such systems at the prototype stage. As a result, dubious programs go into production, at a total cost, estimated by Hewlett-Packard cofounder David Packard, of tens of billions of dollars. Almost every group calling for reform of military procurement practices (including Packard's Blue Ribbon Commission on Defense Management, which reported to President Reagan last year) has called on the Pentagon to insist on the doctrine of "fly before you buy"—that is, to test a prototype of any system fully before making any commitment to purchase it.

There is evidence that the Defense Department is now heeding the call. Last fall, it authorized the Defense Advanced Projects Research Agency (DARPA) in Arlington, Va., to provide early prototyping and proof-of-concept demonstrations for major programs such as new fighters and bombers. The authorization represents an expansion of authority for DARPA, which has traditionally developed new systems to the point of application, and then passed them on to the individual services.

Bolstering this new management approach is a new software-based technique called rapid prototyping. It simplifies the task of putting together prototypes of computer systems for new uses. Because users unfamiliar with computers can rarely specify their needs precisely, prototypes built to their stated requirements often fail to work as expected. Modifying such prototypes costs time and money. Rapid prototyping, pioneered by TRW (Redondo Beach, Cal.), is an interactive means of assembling prototypes that involves users from the start. The initial prototype takes 14 to 30 days to build. Actual operation of the prototype by users enables designers to modify it within days to resemble the final system. According to TRW engineer Larry L. McLaughlin, rapid prototyping can save as much as a third of the life-cycle costs of military systems, and can reduce maintenance costs by more than 40%.



Cost-saving programs that encourage technology transfer among military contractors enhance U.S. industry's competitiveness, claims Westinghouse's Thomas Murrin (left).

The other major cost-control project, RISE 2000, was initiated as a response to ESD's realization that its incentives and warranties varied widely from contract to contract. Overspecification tended to drive up costs unnecessarily, while the effort to ensure the reliability and maintainability of equipment purchased by ESD was mainly controlled by individuals more adept at calculating statistics than at hands-on engineering. According to one count, the division had more than 50 different ways of quantifying reliability, and was depending on more than 45,000 military standards, many of them inconsistent or completely ineffective, to define its purchases.

RISE introduces what Lee Pollock, director of ESD's Systems Readiness Engineering Office, calls a "back-to-basics approach." It involves 14 "methods," or specific, simplified tasks, that define the reliability and maintainability of the finished products. These include the criteria that the contractor must use to develop a reliability plan; the methods to record, analyze, and correct faults; and techniques of environmental stress screening. Thus, instead of trying to follow traditional but often confusing standards and specifications, contractors in the RISE program receive clear instructions on what is expected of them. The approach has already produced dividends. According to Pollock, the reliability of more than 25 ESD programs has increased 25–125% over the first three years of RISE.

A few programs plainly do not make a revolution, particularly in an enterprise as large as the military-industrial complex. Individual overpriced items will continue to bemuse the public, embarrass the Pentagon, and arouse the military's critics. But the early success of new approaches such as Get PRICE, Competition Advocacy, prototyping, and RISE indicates that the Defense Department not only can save taxpayers' money but can do so while improving the quality of the nation's technological base. □

Peter Gwynne is a senior editor of HIGH TECHNOLOGY.

For further information see **RESOURCES**, *p. 64.*



This mountain exists inside a computer, and can be seen on a computer screen. It was built only with numbers. And it exists only because of one man's idea.

The man is Benoit Mandelbrot, a mathematician and an IBM Fellow. And his idea is known by the name he gave it: fractal geometry.

This geometry is a new, non-traditional area of mathematics. Now scientists and artists can create computer images–like this mountain–that have all the quirks and irregularities of natural objects. That wasn't possible before fractals, and it's changing the way we look at the world.



Fractal image by IBM physicist Dr. Richard Voss

Of course, ideas like fractal geometry don't just happen. It takes support and encouragement, which is one reason why the IBM Fellow Program was created. It's a program that gives a select group of IBM scientists and engineers the freedom to take risks, and pursue their ideas wherever they may lead.

Today, there are over 50 IBM Fellows. Their influence on science and computer technology doesn't stop with their innovative thinking.

Because they've also shown us that the freedom to explore ideas can lead to places never imagined before.

IBM

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UNITING SILICON AND GALLIUM ARSENIDE



A thin film of gallium arsenide is grown on a heated silicon wafer at GTE labs.

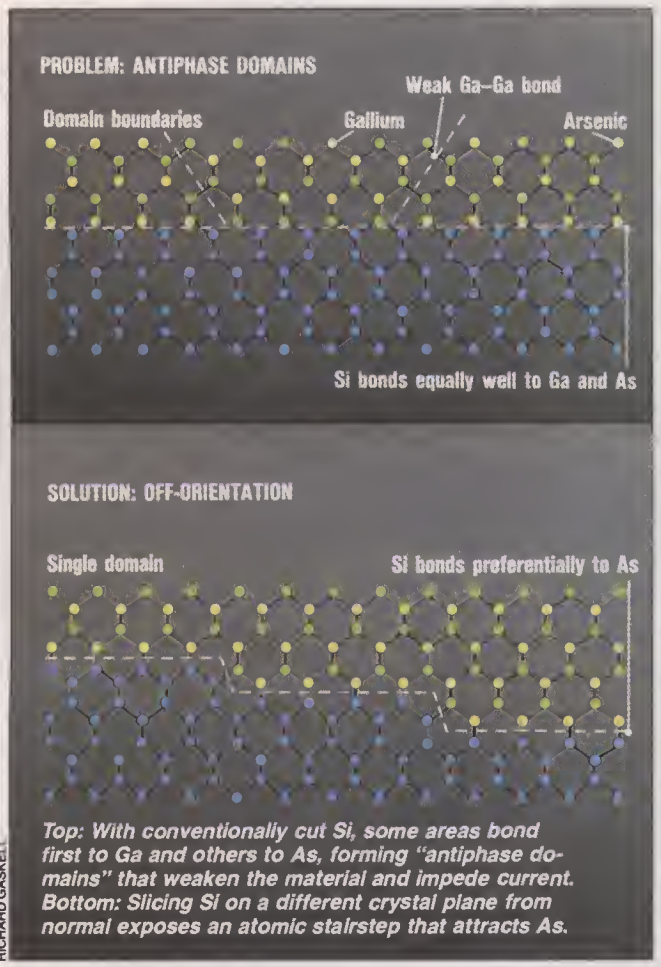
Chips under development combine ease of fabrication with optical capabilities and speed

Silicon is plentiful and easy to work with, but its shortcomings are becoming increasingly evident. It cannot practically be made to emit light, so it is useless for making the lasers and LEDs that form the heart of fiber optics, optical disc readers, and future optical computers. Speed is another limitation. Silicon devices perform poorly or not at all at microwave frequencies (often tens of gigahertz); in digital systems, silicon's relative sluggishness puts a ceiling on the number of bits per second that a circuit can handle.

by John G. Posa

Gallium arsenide shines where silicon slumps. Electrons are about five times as mobile in GaAs as they are in silicon, resulting in proportionately higher operating speeds. Moreover, GaAs devices can emit light, withstand higher temperatures, and survive higher doses of radiation (such as the alpha particles emitted by some electronic packaging materials). Among the latest digital GaAs circuits are ultrafast memories and "gate array" chips, which users can configure into high-speed number-crunching elements. Supercomputer manufacturers are testing these devices in preparation for their next-generation systems, which will employ GaAs for some crucial functions.

Unfortunately, GaAs has its own severe drawbacks: it is difficult to produce and to work with. Whereas silicon crystals can be grown six inches in diameter (and eight-inch crystals are in the offing), GaAs ingots yield substrates barely three



RICHARD GASKELL

Top: With conventionally cut Si, some areas bond first to Ga and others to As, forming "antiphase domains" that weaken the material and impede current. Bottom: Slicing Si on a different crystal plane from normal exposes an atomic stairstep that attracts As.

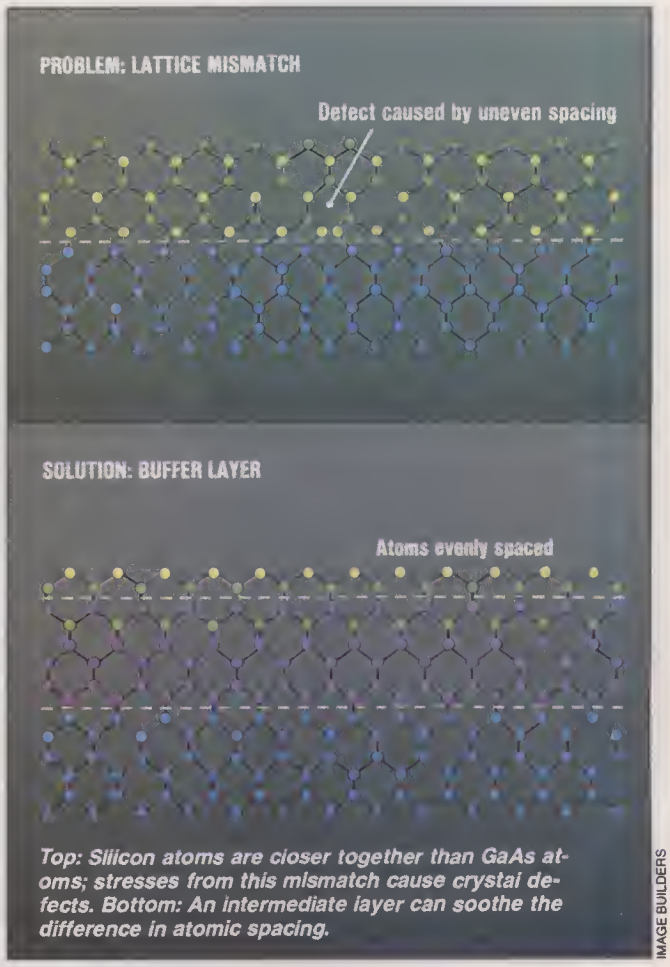


IMAGE BUILDERS

Top: Silicon atoms are closer together than GaAs atoms; stresses from this mismatch cause crystal defects. Bottom: An intermediate layer can soothe the difference in atomic spacing.

inches in diameter. And unlike hard, silvery silicon, grayish GaAs is soft and fragile, tending to break during slicing, scratch during polishing, and chip during handling. Typically fewer than half of the wafers remain intact. Such difficulties have kept gallium arsenide expensive; its use for large integrated circuits has been limited mainly to military systems in which high speed and radiation hardness are essential.

But recent developments suggest that gallium arsenide will ride into the commercial mainstream literally on the back of the now dominant semiconductors. The concept is simple: deposit GaAs on top of silicon to reap the advantages of both materials. The resulting wafers would combine the speed and optoelectronic properties of GaAs with the mechanical ruggedness of silicon. And almost overnight, the process could double the diameter of GaAs starting materials from three inches to six, with an attendant increase in production throughput. With silicon as a stronger base material, gallium arsenide substrates could be processed with far fewer damaged during production, and could be more easily handled by automated tools such as robot arms.

Although no GaAs-on-Si devices have hit the market, activity is widespread; commercialization seems likely during the next 18 months. Texas Instruments (Dallas) recently built a 1-kilobit memory in GaAs-on-Si that performed identically to versions made with straight GaAs. Startup Kopin (Taunton, Mass.) promises production of GaAs-on-Si wafers sometime this year. Nearby, both GTE Laboratories (Waltham, Mass.) and Spire (Bedford, Mass.) are building solar cells in GaAs-on-Si. The two materials absorb slightly different portions of the sun's spectrum, so if they work together they might convert as much as 30% of incoming light into electricity—about twice the efficiency of conventional silicon solar cells.

And the trend toward growing one electronic material on top of another won't stop with GaAs-on-Si. Already, great progress is being made in depositing other materials on silicon—and on GaAs-on-silicon. Ford Aerospace & Communications (Newport Beach, Cal.), for instance, is working with such multilayer structures in order to increase the size of infra-

red detectors used in many military systems. The active ingredient in these detectors—mercury cadmium telluride (HgCdTe)—works best if deposited onto cadmium telluride (CdTe); unfortunately, it is extremely difficult to fabricate large, high-quality CdTe wafers. Ford attacks the problem by starting with a sturdy silicon foundation and coating it with GaAs, a material with which CdTe is more compatible. CdTe is grown on top of the GaAs, and HgCdTe on top of that. Not only can Ford produce bigger sensors this way, but the silicon in the resulting device could be used for signal-processing circuits.

When GaAs and other materials are combined with silicon, each material can handle the tasks it's best suited for. Intelligent camera imagers or flat-panel displays, for example, could mate nonsilicon picture elements with silicon image-processing circuitry. And in fiber optic telecommunications, lasers and light detectors made of gallium arsenide could team up with silicon circuitry that handled memory and signal processing chores, all on the same chip.

For fiber optic systems, lasers and photosensors made of GaAs could team up with silicon circuitry that handles memory and signal-processing chores—all on the same chip.

Taking a step in this direction, researchers at MIT's Lincoln Laboratory recently reported the integration of a GaAs light-emitting diode and a silicon transistor on the same silicon substrate. Such a combination permits very-large-scale ICs to communicate with each other optically, avoiding the electromagnetic interference that plagues electrical interconnections.

An extension of this work could result in a single-chip repeater for fiber optic communications. Light from the fiber would strike a silicon photodetector; the resulting electronic signal would be amplified and perhaps reshaped by other silicon signal-processing elements, and then fed into the GaAs laser, which would launch a light beam into the output fiber. An optoelectronic chip with several inputs and outputs could serve as a crosspoint switch to match parties on the telephone network.

While GaAs-on-Si devices have been demonstrated in the laboratory, several major technical problems are impeding attempts to launch them into the marketplace. Among the biggest difficulties:

- Silicon oxidizes easily. In conventional IC fabrication, the ready formation of silicon dioxide (SiO_2) is helpful; the oxide can be etched to produce insulating layers and masks during device fabrication. But in order for GaAs to adhere, the oxide must be stripped away to expose a bare silicon substrate.
- Gallium arsenide expands with heat about twice as fast as silicon does. Thus the cool-down to room temperature after the high-temperature deposition of GaAs results in a bowed wafer.
- Gallium arsenide can grow in two different orientations, or phases. In some areas of the substrate, gallium atoms are the first to attach to the silicon; in other areas, arsenic lands first. When islands of GaAs from the two types of starting possibilities meet, gallium will hit gallium and arsenic will hit arsenic. These "antiphase" defects hinder the flow of current.
- The atoms in a crystal of GaAs are slightly farther apart than those in silicon; at the interface there are about 24 gallium and arsenic atoms for every 25 silicon atoms. This lattice mismatch accumulates during growth, causing defects.

One way to lessen the effect of the difference in atomic spacing between silicon and gallium arsenide is to introduce a buffer layer of a third material. Germanium, for example, forms a strong alloy with silicon, and its crystal lattice matches that of GaAs. Germanium interlayers have been widely studied—at the University of Illinois (Urbana), the Toyko Institute of Technology, and Nippon Telegraph & Telephone, for example—but the technique is falling into disfavor, in part because germanium atoms tend to diffuse into the GaAs layer, causing undesirable changes in the material's electrical behavior.

In another approach, researchers at Nagoya University separate the GaAs from the Si by a stack of thin layers, each differing slightly in composition from its neighbors. They deposit on silicon a layer of gallium phosphide (GaP). Then comes a series of extremely fine layers of GaAsP, each containing a higher ratio of arsenic to phosphorus, until at the top the material is pure GaAs. This "strained-layer superlattice" gradually relaxes the large lattice mismatch arising from the unequal atomic spacing.

But the advent of new direct-growth techniques may eliminate the need for such superlattice structures. Oki Electric (Tokyo) uses a simple two-step growth process: a relatively thin GaAs layer is grown on the silicon wafer at about 450° C; this layer does not possess good crystalline qualities, but it provides a single strained bond between the silicon and a thicker GaAs film that is deposited on top of it. Oki has fabricated transistors and LEDs on wafers made with this process, and has found that such devices perform identically to those made with pure GaAs wafers. GTE Labs has developed a similar process, and aims to use GaAs-on-Si to build solar cells, high-speed transistors, and digital gate arrays.

Most GaAs-on-Si fabrication involves one of two fabrication techniques: molecular beam epitaxy (MBE) or metalorganic chemical vapor deposition (MOCVD). In MBE, a silicon wafer is heated inside an evacuated stainless-steel vessel. Within the chamber are shuttered cells containing the elements that are to he deposited—that is, gallium and arsenic. Opening the shutters permits atoms to escape from the container; some of them fly toward the wafer and adhere to its surface. In MOCVD, by contrast, the silicon wafer sits in a container at or near atmospheric pressure, and the elements for deposition are contained in such compounds as arsine and trimethyl gallium. Heat from the wafer dissociates the compounds; the molecules' metallic constituents (gallium and arsenic) stick to the wafer while the remaining portion is exhausted as hydrocarbons and hydrogen gas.

MBE is an extremely powerful tool that can grow just about any material onto any other material with extreme precision. The process has several drawbacks, however. For one, the machines are expensive, costing upwards of a million dollars. Also, the need for radically low pressures reduces throughput; even the fastest MBE machines process only a few small wafers at a time, whereas some MOCVD system can handle 10–20 wafers at once. Thus while MBE will continue to be used as the proving ground for new GaAs-on-Si structures, MOCVD appears destined to become a production workhorse.

Although MBE and MOCVD can deposit precise films to ease the lattice mismatch between silicon and gallium arsenide, they do not alleviate the materials' thermal incompatibility, which remains a major hurdle to commercialization. GaAs-coated silicon wafers sometimes bow to a radius of curvature as small as 5.5 meters, according to Ross C. Bean, principal scientist for advanced semiconductor technology at Ford Aerospace; ordinary silicon wafers, he says, are 10 times as flat. The warped wafer is prone to cracks and breakage. As one possible solution to this thermal mismatch, Bean proposes growing GaAs only on those portions of the silicon wafer that will be occupied by the circuitry; GaAs could be etched away from all other areas so that warps would not accumulate.

Right: Silicon substrates "might finally bring gallium arsenide into commercial viability," says Kopin's Paul Smith. Below: Wafers ready for GaAs deposition.



JOHN HUET



DICK ARMSTRONG

Even when fabrication problems are solved, there are some applications for which GaAs-on-Si will not be suitable, at least not right away. This exclusion applies, for example, to devices that rely on the conduction of positively charged "holes" as well as negatively charged electrons—a category that includes certain types of efficient solar cells as well as bipolar transistors. The problem is that the stresses created in the GaAs layer form sites where electrons and holes recombine, degrading device performance.

Another area where GaAs-on-Si might not soon compete with bulk GaAs is extremely-high-frequency analog circuits such as millimeter-wave transistors. These devices require a highly resistive substrate material so that current does not bleed from one device to another on the same chip; silicon is more conductive than GaAs and so leads to poorer performance.

And those who are skeptical about the future of GaAs-on-Si cite the fate of an earlier technology—silicon-on-sapphire (SOS). Such devices were touted as superfast and radiation-resistant alternatives to plain silicon circuits. Despite valiant attempts at commercialization by RCA and other companies, SOS remained too expensive for its speed advantage, and the technology was relegated to costly aerospace programs.

Unlike SOS, however, GaAs-on-Si offers features that are attractive for larger markets. Kopin President Paul Smith predicts that marrying the two premier semiconductors "might finally bring gallium arsenide into commercial viability." Gallium arsenide on silicon, he contends, could garner up to 35% of the GaAs substrate business. Moreover, GaAs-on-Si wafers may have half the defects of those in conventional gallium arsenide production. With silicon as the substrate, Smith maintains, yield could soar to 70–90%; and with breakage less of a problem, GaAs chip makers will eagerly use larger wafers. Smith says that Kopin will offer six-inch wafers of GaAs-on-Si at a price competitive with three-inch gallium arsenide wafers. □

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For further information see **RESOURCES**, *p. 64.*

CAN JAPAN LAUNCH A COMMERCIAL AIRCRAFT INDUSTRY?

What the Japanese have learned from Boeing could land them a slice of the world's airliner market

BY ROBERT POE

The first time Japanese companies and Boeing Commercial Airplane agreed to a joint production effort, the result was a successful airliner, the 767, which went into service in 1982. Now they're collaborating on another plane—the 150-seat 7J7, incorporating radical new technologies and due in 1992. These partnerships have fueled concern that the Japanese will go it alone in coming years with their own aircraft, using know-how acquired from the Seattle aerospace giant.

Japanese government and aircraft-industry officials uniformly deny the possibility—not necessarily because they wouldn't like it to happen, but because they feel that Boeing is too strong a competitor to tackle head-on, and that Japan's domestic base is too small for an aircraft industry.

Many analysts agree. But they caution that Japanese money and technology will nevertheless increase the nation's influence in the civil aircraft business in coming years. The Japanese share in the Boeing partnerships jumped from 15% of the 767 to 25% of the 7J7, reflecting both Boeing's increased need for outside capital and its satisfaction with its Japanese partners in the 767 collaboration. That share is likely to increase further in future partnerships, perhaps to complete equality. And some Western observers have not entirely dismissed the possibility of continued growth resulting in a full-fledged Japanese commercial aircraft industry. A little-noticed General Accounting Office report of March 18, 1982, *U.S. Military Coproduction Programs Assist Japan in Developing Its Civil Aircraft Industry,* stated the concern clearly: "In the post–World War II period, Japan's aircraft industry grew and developed largely through U.S. military coproduction programs. Much of the technology transferred through these programs has commercial application. Now, building on the experience and technology gained through military coproduction programs, the Government of Japan is assisting in the development of the civil aircraft industry, along with other high-technology export industries."

Industrial organization in Japan certainly seems well structured for such technology transfer. The three major airplane manufacturers involved in the Boeing deals, for example, produce both military and civilian products. In a Mitsubishi Heavy Industries (MHI) factory in Nagoya, F-15C and F-15D fighters, produced under license from McDonnell Douglas as the F-15J and F-15DJ, are assembled in the same building as fuselage sections for the Boeing 767 airliner. Kawasaki Heavy Industries (KHI) and Fuji Heavy Industries have similar complementary setups, as does Ishikawajima-Harima Heavy Industries, the leading Japanese engine maker.

Japan has long insisted on a maximum



RICH IWASAKI

Japan Aircraft Development's Atsushi Kasai notes that Japan's first attempt at building its own commercial aircraft taught planners that planes cannot be sold like cars, where a large domestic market assures a break-even point.

of independence in building its military aircraft. "We don't want to be dependent on a foreign country for long-term maintenance and technical support," explains Seiji Ema, director of the aircraft division of the Japan Defense Agency (JDA) equipment bureau. Hence, Japan strives to design and build what aircraft it can by itself. Those it can't it aims to manufacture under license—or, more accurately, "co-produce," since some parts are still imported.

That independence is costly. Licensed manufacture is inherently less efficient than outright purchase, since production runs are shorter and licensing fees must be paid. A single F-15J costs the JDA ¥10 billion (about $40 million), according to Shiuichiro Komatsu, a retired air force major general and defense production consultant to Keidanren, the powerful economic advisory organization. Outright purchase from McDonnell Douglas, by contrast, would cost just above $25 million. Designing new military aircraft from scratch costs even more, because Japan's constitution prohibits manufacturers from selling military goods abroad, thus making it harder for them to recoup their research and development costs. Nevertheless, there are strong indications that the Defense Agency will soon choose domestic development of the FSX, the new supersonic support fighter that it requires, rather than purchase a foreign plane or even allow substantial foreign participation in developing or building a new plane.

The goal of military independence is a strong argument for these extra costs, which can be justified even further if they improve the overall position of Japan's aircraft industry. Undoubtedly the Ministry of International Trade and Industry (MITI) exerts strong pressure on the Japan Defense Agency. "While JDA ultimately decides whether to import or to license-produce foreign military aircraft," according to the General Accounting Office report, "MITI's guidance and recommendations influence such decisions.... MITI's interest in developing and expanding the industry is well served by JDA programs."

The ministry has also taken a more active role in Japan's aircraft industry. Since the 1950s it has provided direct help, by channeling government funds to commercial aircraft manufacturers for various projects. And although government and industry officials these days unanimously preach the gospel of international collaboration in building airliners, the

original intention—embodied in several early projects—was for Japan to become an independent producer of commercial passenger planes.

The first Japanese foray into the field, however, put at least a temporary halt to such plans. The YS-11, a twin-turboprop 60-seat commuter plane, was a technical success but a commercial failure for which the government picked up the tab. Original design work began in 1958, and production started in 1965. The three major manufacturers shared the work, and joined with about 100 other companies to put up 45% of the ¥5.5 billion start-up costs ($15 million at that time). The government paid the rest, and later supplied an additional ¥27.3 billion ($76 million) in direct subsidies, as well as guaranteeing loans from the Japan Development Bank and commercial banks. If the plane had made a profit, all the money would have been repaid; instead the government lost an estimated ¥30–60 billion ($83–167 million), according to Eiichi Hasegawa, deputy director of MITI's aircraft and ordnance division.

One serious problem with the YS-11, contends Masaya Fujisaki, general manager of MHI's aircraft and equipment division, was a lack of sales experience. For example, production was geared more to keeping the factories busy than to meeting market requirements. At one point, 10 planes per month were being built without any orders from buyers, according to Kenji Uchino, vice-president of Commercial Airplane Co., one of several government organizations set up to coordinate Japanese work on specific cooperative projects with overseas companies.

But the major problem, says Atsushi Kasai, senior managing director of Japan Aircraft Development Corp., which is handling the 7J7 project, was the size of the domestic market. "In automobiles and electronics, we break even in Japan, and then we can export," he says. "For [small turboprop] airplanes, the Japanese market was so small that we had to sell [the YS-11] overseas before the break-even point." He adds that overseas prices were "too low"—approximately half of their production cost—because of competition from the Dutch Fokker F27, a 40-passenger plane. Given the mounting losses, production was stopped in 1974 at just over 180. "Less than half" had been sold in Japan, including those for military use, according to Kasai.

By that time, work had started on a larger domestically developed airliner, the YX. However, as the magnitude of the YS-11's commercial failure became clear, the project was reevaluated. Through another nonprofit group, the government looked into possible joint projects with all the major competitors at the time: Airbus, Lockheed, McDonnell Douglas, and Boeing. It ruled out Airbus because of complications with European governmental involvement, and turned down Lockheed and McDonnell Douglas because they were interested only in collaborating on derivative versions of existing planes. Boeing's proposal was closest to what the Japanese had in mind—a completely new airplane—and in 1978 the two parties entered a risk-sharing agreement for coproduction of the 767, a wide-bodied 200-passenger twin-engine airliner that is still often called the YX in Japan.

The Japanese produce body sections that represent 15% of the value of the 767—in practical terms, most of the fuselage. Although the agreement was for coproduction rather than codevelopment, Mitsubishi, Kawasaki, and Fuji dispatched more than 130 employees to Seattle during the plane's development. Of the 50 Kawasaki people, 30 were engineers who were to help design the body sections so that they could be easily produced in Japan. In addition, says Toshio Hiraki, general manager of KHI's aircraft engineering division, "they were under MITI's orders to learn all they could about the technology."

Although government and aircraft-industry officials now preach the gospel of international collaboration, the original intention was for Japan to build its own airliners.

What benefit did the partnership bring Boeing? Willard Hughes, head of Boeing's Tokyo office, contends that, despite their initial concerns, without the partnership the Japanese would have collaborated with Airbus or McDonnell Douglas, and would thus have ended up in competition with Boeing. The partnership also provided Boeing with access to the world's second-largest market for jet transports (as opposed to small turboprops). Early in 1986, for example, All Nippon Airways—which the *Japan Economic Journal* says was under indirect pressure from the government (via the aircraft manufacturers) to buy from Boeing—ordered twenty-five 767-300s, worth more than $2 billion, instead of the Airbus 320s that it seemed to prefer.

Although airlines' orders for the 767 did not pour in as fast as expected, the project has worked out far better financially for the Japanese than did the YS-11. The government has already received about 40% of its ¥15 billion ($60 million) share of the production costs, according to Hasegawa, and expects to get back the full amount.

In the early '80s, with a seemingly successful collaboration on the 767 under their belts, the Japanese were in a stronger bargaining position for their next project. According to the Society of Japanese Aerospace Companies, their participation was actively solicited by McDonnell Douglas and Fokker for their MDF-100 project, by Airbus for the A-320, and by Boeing, which needed a partner to share the ever-increasing cost of developing new planes. The Japanese companies eventually reached an agreement with Boeing that included full participation not only in production but also in development, sales, and service. They would put up 25% of the money and manufacture 25% of the 7J7. A "memorandum of understanding" signed March 6, 1986, formalized the arrangement.

The government also changed its funding method, in response to estimates that the cost of developing the 7J7 could soar as high as $2–4 billion. Since July 1, development funds have come from Japan Development Bank loans rather than direct government subsidies. To smooth the transition, however, the government is paying the loan interest, subject to the same provisions as earlier subsidies—it must be repaid from revenues as they are generated. But the loans must be repaid no matter what the project's commercial fate.

In an attempt to ease foreign fears that Japan is targeting commercial aircraft, MITI has made one more significant funding change. Last May 22, it created the nonprofit International Aircraft Development Fund to disburse future government funds for aircraft development. Money from the fund can be used only for international collaboration; purely domestic projects are excluded. Provisions are also being formulated to include participation by foreign companies, although American observers do not expect overseas partners to have much voice in disbursement decisions.

It's too early to tell whether this new funding route will stem foreign suspicions, which have generally comprised a two-part scenario: the Japanese will absorb Boeing's advanced technology, and then they will use it to build their own



RICH IWASAKI

Japan lacks experience in systems integration, argues Mitsubishi's Masaya Fujisaki.

competitive airliners. The first part will undoubtedly happen—Boeing has decided to give the Japanese full access to the new plane's state-of-the-art technology. But the second point remains uncertain. Japanese officials list several reasons why they will not try to build their own airliners. Significantly, however, their arguments concentrate on a perceived inability, rather than a lack of desire.

"We Japanese don't have much experience in large systems integration," says Mitsubishi's Fujisaki in a typical response, even though his company and similar Japanese firms have built some of the largest crude-oil supertankers in the world, as well as oil rigs, refineries, and other plants. MITI's Hasegawa asserts that the three aircraft firms combined do not have the financial means to take on such a major project. In reality, however, they are large and prosperous when all their activities are taken into account. Mitsubishi Heavy Industries reported 1985 sales of $13.8 billion, for example, and Kawasaki Heavy Industries $2.8 billion. Boeing's figure for '85 was $13.9 billion. As world shipbuilding demand fades, the heavy-industry companies will need to diversify to maintain revenues and find new work for their employees.

A more convincing Japanese claim is that they lack expertise in selling large products such as airliners. They clearly have a lot to learn, and Boeing is the obvious tutor. "We know they want that from us," says Hughes. Will they get it? "Yes," he replies. "They are full partners."

But can they take sufficient advantage of that partnership to create their own commercial aircraft industry? And do they want to? At least one straw in the wind suggests that they are seriously considering the possibility.

Last August 15—a symbolic date because it was the anniversary of the end of World War II—the Aviation and Electronics Technology Council of Japan's Science and Technology Agency (STA) recommended that Japan develop a fuel-efficient subsonic 100- to 200-passenger jet. This craft would be 50% more fuel-efficient than the Boeing 767. STA has nowhere near the clout of MITI; its main role is to promote specific technologies by undertaking test projects and making the results available to industry. But the agency has collaborated with MITI, most



RICH IWASAKI

If Boeing doesn't work with Japan, claims Willard Hughes, its competitors will—to Boeing's disadvantage.





RICH IWASAKI

Japan's effort to build its own aircraft lost millions of dollars, says Commercial Airplane's Kenji Uchino, because it aimed more to keep factories busy than to meet market requirements. By contrast, the 767 project (top), which benefits from Boeing's marketing savvy, is paying off despite slower-than-expected orders.

recently to develop the Asuka quiet short takeoff and landing plane (HIGH TECHNOLOGY, April 1986, p. 68). Thus, some U.S. aerospace executives in Tokyo suspect that the proposal may be a trial balloon. If the political climate is favorable, STA can quietly carry out the preliminary research until MITI feels confident enough to step in and make the plane an officially announced goal. But if the proposal runs into heavy foreign opposition, the ministry can claim innocence of any connection with the idea.

On the other hand, industry analysts can find plenty of reasons, in history and economics, for the Japanese not to go it alone. "The Japanese are not anxious to repeat the kind of experience they had with the YS-11," says Christopher Demisch, an aerospace analyst at First Boston (New York). "And they want to avoid the headache of the pure export market that they have to enter alone." The cyclical nature of the aerospace industry will also play a role in Japanese thinking. "They are nervous about its effect on employment," says a former official at the U.S. embassy in Tokyo. "They wouldn't want the unemployment that happened in Seattle to happen to Nagoya." Then there's the huge investment in sales networks and worldwide maintenance facilities that an independent aircraft industry would demand. That couldn't happen, says an aerospace analyst from Nomura (Tokyo), "until well into the 21st century." Overall, says Demisch, "I'd be very surprised if the Japanese go for an all-Japanese solution."

Then how will the Japanese apply their growing financial and technical muscle in the commercial aircraft business? Most likely through fresh international partnerships, which have the dual advantages of spreading out financial risk and increasing opportunities for domestic sales. In addition to the 7J7, the Japanese are already participating in an international consortium to develop aero engines. The next step, according to Demisch, will probably be a near-term partnership agreement on a successor to the 747. Looking farther ahead, Mitsubishi, encouraged by MITI, is carrying out preliminary work on space plane technology, in anticipation of joining the U.S. project to develop a craft capable of both reaching orbit and transporting passengers anywhere in the world within two hours (HIGH TECHNOLOGY, July 1986, p. 46).

The Japanese will undoubtedly use their experiences in the 767 and 7J7 collaborations as leverage for stronger partnership roles in negotiations with Boeing and other Western companies. "They like the security of working with established firms," says the former official in the Tokyo embassy. "But I think they'll try to internationalize as a full, not a junior, partner." MITI's Hasegawa concurs. "We hope the Japanese manufacturers will eventually be the equal partner of Boeing," he declares.

Thus, the U.S. aviation industry could still find itself competing with the Japanese—but for production share, rather than market share, of the same aircraft. In any case the victims will not be Boeing and other aircraft manufacturers but their subcontractors. "The people who have to worry are the suppliers to Boeing," says the former U.S. embassy official, "because Boeing is finding the quality of Japanese suppliers good. The question is: What percentage of Boeing planes' production will go abroad?" □

Robert Poe, who lives in Tokyo, reports regularly on Japanese technology.

For further information see **RESOURCES**, *p. 64.*

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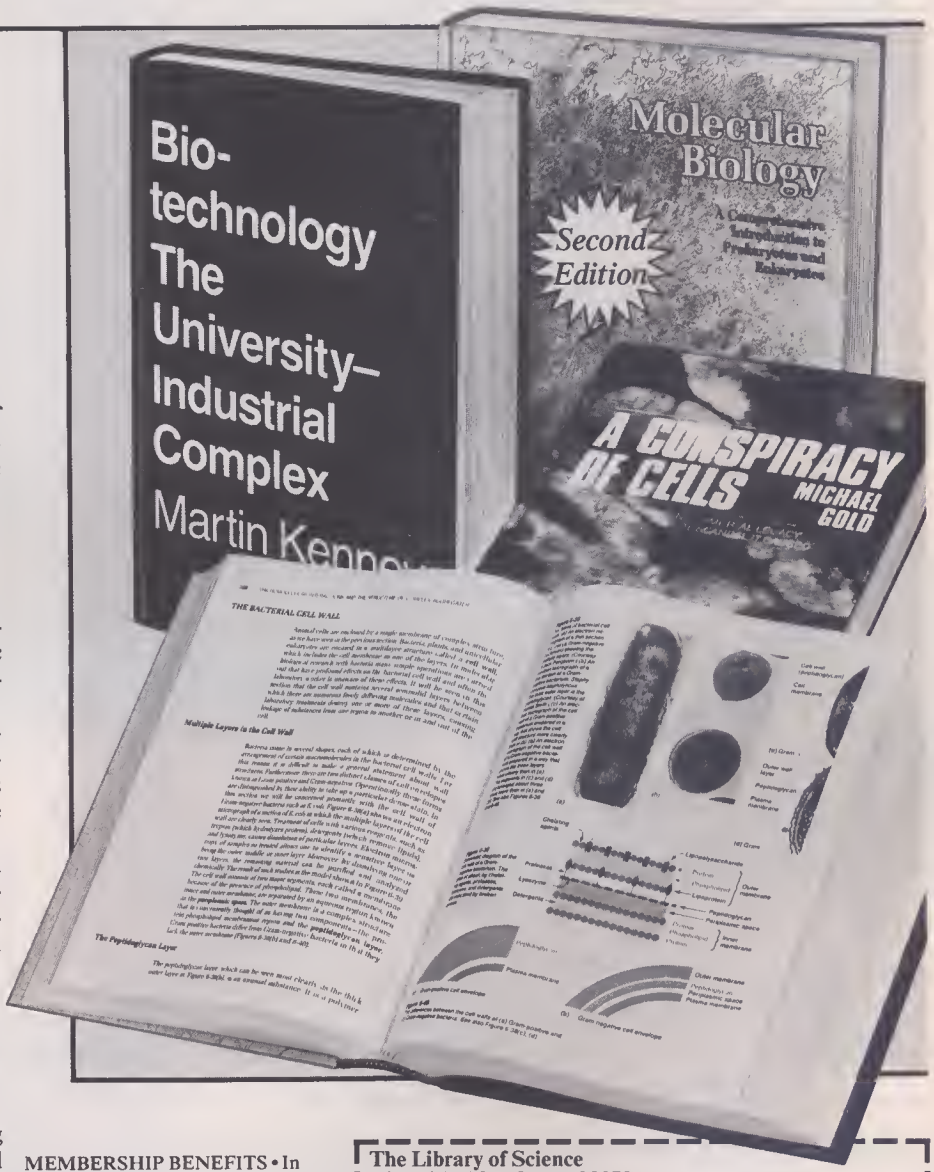
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High Technology 3/87 2-BV3



Alexandria, Virginia

Historic Seaport City Emerges as Prime Address for High Technology Industry.

by Richard M. Flaherty

High technology has had a phenomenal impact on the growth of the greater Washington, D.C., marketplace in the 1980's and will continue to spur expansion into the 1990's and beyond. The rising prominence of this region as a center for high technology can be seen most dramatically in Alexandria, Virginia. In 1985, almost two million square feet of office space were leased or purchased in Alexandria by new or expanding businesses. Historically a center of commerce and shipping for the mid-Atlantic region, Alexandria today has become a choice address for national and international high technology corporations.

A cross section of companies with headquarters or major divisions in Alexandria include AT&T Communications, Inc.; Essex Corporation; Computer Corporation of America; TRW; Control Data Corporation; Fokker Aircraft, U.S.A., Inc.; Softech, Inc.; Abex Defense Systems; Technology Applications, Inc.; Allen Corporation of America; and the Center for Naval Analyses, a subsidiary of the Hudson Institute, also headquartered in the city.

Electronic Business magazine's annual listing by sales of the top one hundred electronics firms nationwide confirms the region's popularity as a center for high-technology. Eighty-five of the top one hundred companies presently maintain offices in the area.

The region's market for computer technology is equally as strong. Overall it is the fourth largest computer installation center in the nation. In 1982 alone the value of computer systems, almost $3 billion, ranked the region among the top four locations in the nation, along with New York, Chicago and Los Angeles. In addition, statistics also reveal that the metropolitan Washington marketplace is swiftly becoming the "information capital of the world" with more than two hundred telecommunications-information companies as well as many law, management and consulting firms

TransPotomac Canal Center, a half-million square-foot commercial development on the Potomac River waterfront in Alexandria, Va., is an example of the new large-user developments attracting high tech companies to Alexandria.



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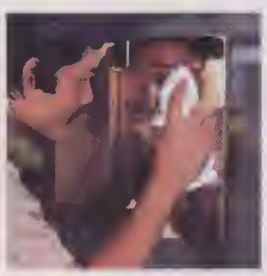
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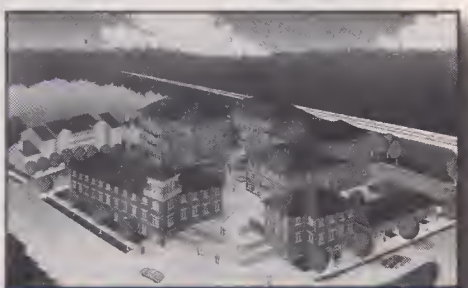
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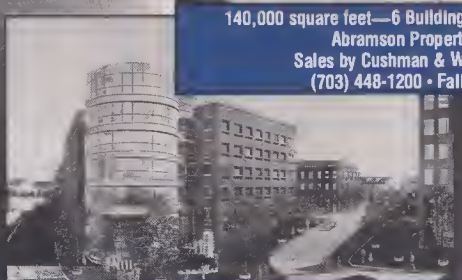
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A L E X A N D R I A V I R G I N I A

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An examination of the factors involved in the high tech industry's decision to locate to Alexandria reveals a sophisticated set of criteria at work in the site-selection process. Geographic location, transportation facilities, a lower cost of doing business, a skilled labor force, exceptional educational/research and development resources and the quality of life all contribute to the choice of this region over more renowned high tech meccas.

Location is a Key Factor

Alexandria is located in the center of the Baltimore-Washington Common Market (BWCM), the fourth largest metropolitan area in the nation with more than two million households. The city is served by three major airports, thirty-seven general aviation airports, the nation's third largest port, five major and three shortline railroads and nine interstate highways.

Often compared to California's Silicon Valley, North Carolina's Research Triangle and Massachusetts' Route 128 belt, Alexandria has the unique advantage of being the major high tech center in closest proximity to the top-ranked purchaser for all high tech products—the federal government. Being located virtually in sight of the U. S. Capitol gives the region's high tech firms easy access to such principal clients as the Department of Defense, the Department of Energy, the National Aeronautics and Space Administration, the National Institutes of Health, the Federal Aviation Administration, and the Coast Guard of the Department of Transportation. Federal expenditures in the metropolitan Washington area alone in fiscal year 1985 totalled approximately $38.6 billion.

"The convenience of Alexandria is just outstanding," says Phillip Baker, vice president of Softech, Inc., a software service company which recently leased 95,000 square feet of space in the city. "Since we primarily do work with the Department of Defense, we needed a location that was close to Washington, the Pentagon and the airport. In Alexandria, we get the convenience we need in a beautiful setting."

Many of Alexandria's new developments are located within walking distance of the city's three Metro stations. Additional choice physical settings can be found in the city's Old Town courtyard office projects, in larger office complexes located right on the Potomac River waterfront, in campus or park settings in the city's west end, and in high technology centers like the Alexandria Tech Center completed in 1986.



The Mark Center provides a campus-like setting for high technology firms desiring close proximity to the Nation's Capital.

Lower Cost of Doing Business

Another key criterion cited in the selection of Alexandria is the financial consideration. Numerous equity and purchase opportunities exist in Alexandria, and with space currently leasing at $12 to $25 per square-foot, compared to $18 to $44 in downtown Washington, Alexandria has become a particularly strong leasing market as well. "While our space available for purchase continues to grow, we are also developing nearly one million square feet of leasable space annually," says G. Barton Middleton, trustee of Alexandria's Economic Development Program.

Other financial incentives for relocating to Alexandria come from the city's pro-business government. Thomas E. Anger, Director of Finance and Administration for the Center for Naval Analyses, explains, "The Center chose to move to Alexandria because the city doesn't impose gross receipts tax on operations like ours." This factor has assisted in attracting more than one hundred technology firms to Alexandria.

Many businesses have also been helped by special financial programs that are available through the city's Mount Vernon Avenue Revitalization Fund, the Northern Virginia Local Development Company, local venture capital firms, the Commonwealth of Virginia and various federal agencies. In addition, new programs have been developed to supplement federal and state loan programs to provide venture capital and financial assistance to businesses.

The city's business environment also benefits from its location in the northernmost right-to-work state which guarantees reasonable wages, more cost effective support services, and savings in unemployment and worker's compensation insurance expenses. Virginia also offers a tax rate that a report by the Federal Advisory Commission on Intergovernmental Relations ranked seventh in the nation in fostering a pro-business tax climate and first in its fairness in property-tax structure.

Skilled Labor Force

The rapid growth of the high technol-

ogy industry has also created an urgent demand for highly skilled labor. The Washington area has a labor supply that satisfies the needs of all high technology fields. The region has a total labor force of approximately 2.9 million people, two-thirds of whom are employed by the private sector. Over 107,300 of the scientist-engineer work force segment reside within the region and an additional 103,000 scientists live in outlying areas, but within easy reach of the central business districts.

As part of the Washington metropolitan area, Alexandria is located in the center of the best-educated work force in the country. Almost 33 percent of its population have earned college degrees, compared with 18.8 percent in other top metropolitan areas. The region also contains the greatest number of professional and technical workers, managers and administrators of any of the top ten metropolitan areas in the nation.

Education/Development and Research Resources

Alexandria draws its labor force from more than sixty institutions of higher learning, college extension programs and a widespread community college network throughout the District of Columbia, Maryland and Virginia. Twenty-eight of these schools offer degree programs in high technology and fourteen of the schools offer advanced degrees. The supply of business school graduates, equally as important to high technology as research and development, is provided by ten of the region's schools with MBA programs.

Federal funding of scientific research by area public and private educational establishments is greater than similar federal expenditures in other locations with the exception of California. The area's five universities which sponsor concentrated research programs accounted for an estimated $10.9 million in federal research grants for over four hundred and forty engineering research projects in fiscal year 1982. Total funding of these projects amounted to $14.2 million. Independent laboratories and joint programs received an additional $196.8 million in federal and other funding.

A comprehensive listing of educational programs tailored to the needs of the high technology industry is available in the region. These offerings are complemented by the Commonwealth of Virginia's Research and Educational Services. In addition, the state provides educational assistance programs and pre-employment or on-the-job training to meet a company's requirements.

Quality of Life

Finally, in Alexandria the diversity of a major metropolitan area is coupled with the excitement of an historic port to offer an outstanding quality of life. The variety of excellent restaurants, shopping areas, marinas and cultural attractions is unequaled. Housing options cater to a wide range of tastes from intown estates, to historic townhouses, to the Colonial homes of the west end, to upscale high-rises. So while cranes and construction sites are becoming as familiar to Alexandria residents as historic buildings and cobblestone streets, developers and the Alexandria government are careful to assure that the new construction and the area's historic character will continue to coexist harmoniously.

Richard M. Flaherty is director of Alexandria's Economic Development Program.

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Vision Breakthrough

When I put on the pair of glasses what I saw I could not believe. Nor will you.



They look like sunglasses.

By Joseph Sugarman

I am about to tell you a true story. If you believe me, you will be well rewarded. If you don't believe me, I will make it worth your while to change your mind. Let me explain.

Len is a friend of mine who has an eye for good products. One day he called excited about a pair of sunglasses he owned. "It's so incredible," he said, "when you first look through a pair, you won't believe it."

"What will I see?" I asked. "What could be so incredible?"

Len continued, "When you put on these glasses, your vision improves. Objects appear sharper, more defined. Everything takes on an enhanced 3-D effect. And it's not my imagination. I just want you to see for yourself."

When I received the sunglasses and put them on I couldn't believe my eyes. I kept taking them off and putting them on to see if indeed what I was seeing through the glasses was indeed actually sharper or if my imagination was playing tricks on me. But my vision improved. It was obvious. I kept putting on my cherished $100 pair of high-tech sunglasses and comparing them. They didn't compare. I was very impressed. Everything appeared sharper, more defined and indeed had a greater three dimensional look to it. But what did this product do that made my vision so much better? I found out.

DEPRESSING COLOR

The Perception sunglasses (called BluBlockers) filter out the ultraviolet and blue spectrum light waves from the sun. You've often heard the color blue used for expressions of bad moods such as "blue Monday" or "I have the blues." Apparently, the color blue, for centuries, has been considered a rather depressing color.

For eyesight, blue is not a good color too. There are several reasons. First, the blue rays have one of the shortest wavelength in the visible spectrum (red is the longest). As a result, the color blue will focus slightly in front of the retina which is the "focussing screen" onto which light waves fall in your eye. By eliminating the blue from the sunglasses through a special filtration process, and only letting those rays through that indeed focus clearly on the retina, objects appear to be sharper and clearer.

The second reason is even more impressive. It is not good to have ultraviolet rays fall on our eyes. Recognized as bad for skin, uv light is worse for eyes and is believed to play a role in many of today's eye diseases. In addition, people with contact lenses are at greater risk because contacts tend to magnify the light at their edges thus increasing the sun's harmful effects.

Finally, by eliminating the blue and uv light during the day, your night vision improves. The purple pigment in your eye called Rhodopsin is affected by blue light and the eyes take hours to recover from the effects.

SUNGLASS DANGER

But what really surprised me was the danger in conventional sunglasses. Our pupils close in bright light to limit the light entering the eye and open wider at night—just like the aperture in an automatic camera. So when we put on sunglasses, although we reduce the amount of light that enters our eyes, our pupils open wider and we are actually allowing more of the blue and ultraviolet portions of the light spectrum into our eyes.

BluBlockers sunglasses are darker at the top to shield out overhead light. The lens used is the CR-39 which most eye doctors will tell you is one of the finest materials you can use for glasses and is manufactured under license.

The frames are some of the most comfortable I have ever worn. The moulded nose rest will fit any nose. The hinge causes the frames to rest comfortably on your face and can be adjusted for almost any size face.

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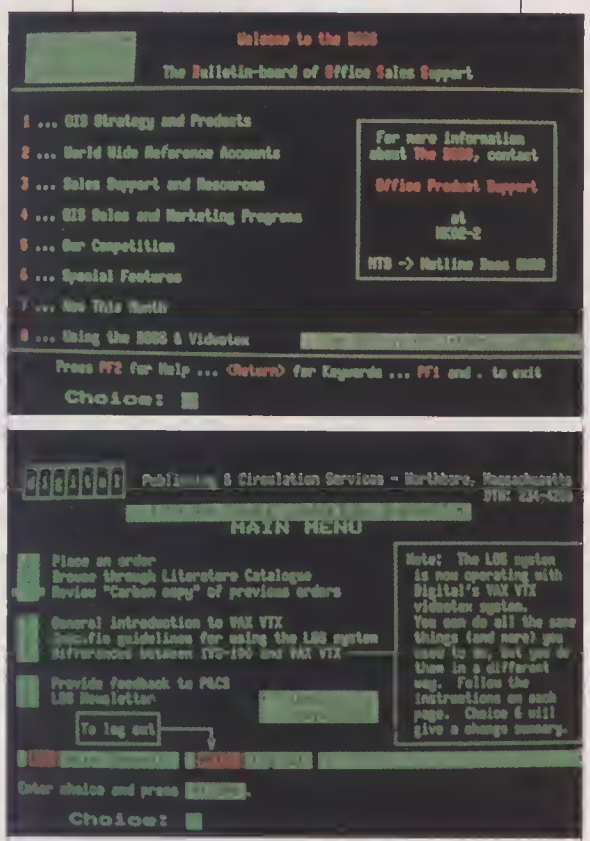
Videotex—computer-based textual and graphic information formatted on discrete pages for electronic distribution and display—has not caught on in the American home, its initial target. However, the technology is becoming a popular business tool, with companies turning to videotex to present information to employees, to communicate between the home office and field personnel, and to provide a variety of business services.

In some of these roles, videotex performs tasks normally handled by traditional database management systems, but the technology is not intended to replace them. Rather, information stored in existing databases may be selectively excerpted for presentation on easy-to-access videotex pages. Videotex can also perform functions uncommon in traditional database management systems, such as providing maintenance personnel with diagrams and instructions to assist them in repairing factory-floor machinery. And while database management systems usually require users to have some programming skills, videotex is accessed with relative ease.

In fact, most videotex systems sold to the corporate market today are designed so that office secretaries can create and maintain databases with little training or technical support. For example, the systems automatically format information from word processors into videotex pages. Producing pages that combine text and graphics is more complicated, but is still simple enough that it can be done by graphic artists rather than programmers. Most of the mechanics of maintaining a database, such as tracking usage and renumbering pages, are fully automated.

In use, the numbered and indexed pages serve as a sort of electronic magazine. To find the corporate helicopter schedule, for example, users might start with "Corporate Services" on the master menu. From this, they might successively select "Transportation" and from that the "Helicopter Schedule."

This process is easy for novices, but it can seem frustratingly slow for those more proficient with the system. Therefore, database designers usually attach mnemonic code words to pages. The helicopter schedule page might be retrievable as "Chopper Schedule," which could be typed in to call the appropriate page immediately to the screen. Some systems also allow users to search the entire database for specific information. This capability is useful in finding data that might be stored on several pages at once.



Digital Equipment's in-house videotex system includes the Bulletin Board of Office Sales Support (top), which assists salespeople in the field, and the Literature Order System, an electronic catalog of product information.

Four major U.S. vendors sell corporate videotex systems. Those from Digital Equipment (Merrimack, N.H.), Honeywell Information Systems (Schiller Park, Ill.), and Prime Computer (Natick, Mass.) are minicomputer-based; the fourth, from IBM (White Plains, N.Y.), runs on that company's 370 mainframe computers. Of these vendors, only Digital Equipment developed its own system. Honeywell, Prime, and IBM license systems that were developed by other companies.

So far, Digital's VAX VTX system is the market leader, with more than 400 systems installed. Prime and Honeywell, meanwhile, have each sold about 50 of their systems. IBM declines to release sales figures for its Videotex/370 system, licensed from Videodial (New York), but *VideoPrint*, an industry newsletter published by International Resource Development (Norwalk, Conn.), reports that only about five systems have been sold.

One reason for IBM's relatively poor showing, suggests Paul F. Deninger, VP for marketing at Disc International (whose Viewbase system is being marketed in the U.S. by Prime), is that the 370 mainframe environment requires the videotex database builders to have programming skills. The Videotex/370 system is also more expensive than that of the competition, with each software license priced at $85,000.

A license for the VAX VTX software, by comparison, costs between $9000 and $75,000, depending upon the type of VAX hardware the system uses. Prime sells the Viewbase software in two size configurations for $27,500 and $40,000. Honeywell's French-developed Infonow package ranges from $120,000 to $350,000, but this price includes the host minicomputer, software, disk storage, and a high-speed printer. The company declines to break out the cost of the videotex software.

Although corporate videotex systems have been around for several years, the market did not begin to heat up until 1986. The delay was caused mainly by the need to educate customers about the potential

by G. Berton Latamore

of the technology—commonly perceived as a home-consumer service—in business applications.

So far, Fortune 500 companies have been the biggest purchasers. General Foods (White Plains, N.Y.), for example, uses its Videodial system to provide the latest sales figures, by product line, to its top executives. Not all the corporate applications are internal, however, or limited to large corporations. Videotex has also spawned various business-to-business services that provide current information directly to users' terminals. Moody's Investors Service (New York), for instance, uses a VAX VTX system to transmit the latest debt ratings on corporations electronically to on-line customers.

The range of potential applications for corporate videotex has prompted *VideoPrint* to predict that more than 23,000 systems will be sold by 1990, representing a total value of $1 billion in software alone. It also predicts that Digital will retain its leadership position, selling 8500 VAX VTX systems by 1990.

An important factor contributing to the increased interest in videotex is the simplification of the standards issue. Several videotex standards exist worldwide, including the British Prestel, the French Antiope, and the Japanese Captain. But the U.S. business videotex market is focused on just two: ASCII—the text-only communications standard that is common to virtually all computers and terminals—and the North American Presentation Level Protocol (NAPLPS), which provides high-level graphics using graphic "primitives" such as tiny lines, angles, and curves.

ASCII is attractive to text-only services because it is less expensive and can be received on virtually all existing computer terminals and PCs without special software. NAPLPS requires expensive terminals or terminal emulation software that runs on PCs, but it allows services to render high-quality graphics. For instance, Clark Equipment (Buchanan, Mich.) has developed an electronic catalog with on-line ordering for its dealers nationwide. It uses NAPLPS graphics to provide pictures of parts, supplier logos, and other graphic information.

"Initially, customers want to pick one standard—either ASCII or NAPLPS—but they want the flexibility to change," says Disc International's Deninger. "NAPLPS buyers who expect future expansion want the escape route of an easy switch to ASCII if the price of NAPLPS terminals never comes down. On the flip side, if they initially go for an ASCII system, they feel they might want to upgrade to NAPLPS." Customers with international operations might also want access to some of the foreign videotex standards. System providers answer the need for system flexibility by making their software multistandard. DEC, which has taken the most rigorous approach to multiple standards, designed VAX VTX so that all the code specific to the videotex standard is isolated in a single, replaceable software module.

Multiple standards also permit companies to use several kinds of terminals with one videotex system. "Terminal populations on most systems are mixed," notes Deninger. "The ability to have PCs of any type—ASCII terminals, graphics terminals, graphics PCs, and special videotex terminals—all accessing the same database at the same time is critical to most users."

Still, the terminals must be compatible with the videotex standard of the page being displayed. NAPLPS terminals can display ASCII pages because ASCII is a subset of NAPLPS. The reverse, however, is not true. Nor, for example, can a French terminal designed for the Antiope standard display ASCII, because Antiope calls for 40-column screens while ASCII uses 80 columns. To obtain the most flexibility, videotex systems commonly turn to personal computers, which are able to run software that lets them emulate the required type of terminal. An additional benefit of using PCs as terminals is that companies can further exploit the machines already on their employees' desks.

A drawback to the use of PCs, however, is that it is difficult to justify purchasing them for all employees; meanwhile, many lower-level employees who do not have their own PCs are exactly the ones who need the videotex information. Honeywell hopes to capitalize on this situation by selling low-cost, easy-to-use terminals designed specifically to work with its Infonow software.

Infonow's Minitel terminals—made by French communications giant Telic Alcatel—originally operated with only the French Antiope videotex standard, and early Infonow installations were also limited to that standard. However, last year Telic announced dual-standard terminals that use plug-in boards to allow them to display pages in a standard besides Antiope. Last fall Telic introduced an Antiope/ASCII version specifically for the U.S. market, and is rumored to have a NAPLPS version in the works. Honeywell's Infonow software will also work with PCs and data terminals—provided the hardware can display the standard used in the particular videotex database being accessed. Unlike the other vendors' videotex software, which can run as one of several packages executing on the same computer, Infonow must run as the only application on its host computer. Honeywell chose this dedicated approach so that it could ensure rapid system response times, says Raymond T. Oschger, program manager for videotex at the company. A system can become overloaded if it must handle several applications simultaneously, he notes. "But we think occasional computer users must receive quick responses."

Prime and IBM, like Honeywell, market

Corporate Videotex With Sunday Tea

Although European countries have had greater success than the U.S. in establishing videotex services for home consumers, they are not ignoring the business applications of the technology. In fact, Viewbase, a system from Disc International (Stamford, Conn.), was initially created by the Debenhams Group, a large retail chain in Great Britain, to provide its directors with the latest sales information. Every Friday the managers of each Debenhams department store transmitted detailed reports of the week's sales to the company's central data-processing facility, where they were combined into a unified report on Saturday. On Monday mornings the board of directors would meet to go over the figures and determine corporate response to changes in the marketplace. The problem was that the printed reports could not be distributed to the directors before their meeting, so they were unable to review the figures.

The Viewbase system permitted the design of preformatted pages with blanks for figures. Each page has two "sides"—a front for viewing by users and a back to hold commands that the system executes automatically each time the page is accessed. These commands can, for instance, tell Viewbase to access a particular sales figure in the database and copy it into a particular blank on the front side of the page. Debenhams used Viewbase to create an electronic weekly sales report that its directors could access every Sunday afternoon from their homes using small videotex terminals. As a result, the directors can now go to board meetings knowing what has happened the preceding week.

their systems primarily as stand-alone products. Digital, on the other hand, has integrated VAX VTX with much of its VAX software. One popular use of VAX VTX is with Digital's All-in-1 office automation system, where videotex appears on the main function menu as an electronic reference library, and can be accessed directly from other All-In-1 functions. Users composing letters on All-In-1's word processor, for instance, can jump directly to a page on the VAX VTX system and copy it into their documents. In another application, VAX VTX has become the center of a facilities management system that DEC sells to large manufacturers. This system allows users to draw a detailed map and diagram of their factory floor in NAPLPS graphics, showing the location of every machine, electric outlet, and other important feature on the floor plus conduits hidden beneath its surface.

Videotex systems are easy to build and can be accessed by novice users.

In addition to leading the market with its videotex system sales, Digital is itself a major user of VAX VTX. The company has built the world's largest private videotex system—spanning five continents and encompassing more than 100 databases. It includes, for example, a set of services for its salespeople that extends into every DEC field sales office in North America. As a result, every Digital salesperson is intimately familiar with the system—which has undoubtedly helped the company attain its lead in the market.

VAX VTX represents a major developmental effort on Digital's part, but one that sales are justifying. "We thought from the beginning that the business market was where the action would be," says William M. Carlisle, manager of videotex market development. "Now that's proving true." □

G. Berton Latamore, based in Burlington, Vt., is editor of VideoPrint, *a newsletter on electronic publishing.*



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HOME-HEATING ADVANCES SAVE ENERGY DOLLARS

Since the energy crunches of the '70s, manufacturers of residential heating systems have been pushing their products to higher and higher efficiencies: furnaces now on the market convert as much as 97% of their fuel energy into useful heat. Moreover, home systems are increasingly combining multiple energy functions—such as space heating, water heating, even electricity generation—in a single piece of equipment.

"Cogeneration" of heat and electricity is often associated with industrial-scale processing (HIGH TECHNOLOGY, Feb. 1987, p. 57), but over the past decade scaled-down systems have appeared in small establishments such as restaurants and Laundromats. Now such equipment is being brought into the home.

Home cogeneration systems consist of a small internal combustion engine—generally fueled by natural gas or propane—connected to a 5–10-kilowatt generator. The systems convert about 25% of the fuel energy into electricity, an efficiency comparable to that of any generator. But cogenerators harness, rather than dump, some of the "wasted" heat energy: the water that cools the engine circulates into a storage tank, from which it can be piped through heat exchangers to warm the house, its potable water, even a swimming pool or hot tub. Typically, about 80% of the fuel energy is transformed into either electricity or useful heat.

Two companies—Thermex (Anaheim, Cal.) and Van Weld (Albuquerque, N.M.)—offer cogeneration systems for the single-family residential market. Van Weld makes a generator that operates at a factory-set frequency and voltage. These "synchronous" machines need no input from the power grid and are thus well suited for remote locations where utility power is absent or unreliable. Thermex's induction generator, on the other hand, must be plugged into the grid in order to work. Induction generators are somewhat less expensive than synchronous, though. Both types can feed excess electricity back into the grid using additional interconnection equipment. The utility is required to buy back this power under the provisions of the Public Utilities Regulatory Policy Act of 1978 (PURPA).

Industrial cogeneration systems occupy entire buildings and use engines large enough to power an aircraft. The residential units, by contrast, are about the size of a small refrigerator; typically they are mounted on a concrete slab outside the house. Experience gained in making industrial cogenerators has decreased engineering costs and helped make smaller systems commercially feasible, although a residential cogeneration system still costs about $10,000–$15,000 installed, considerably more than the most expensive gas furnaces. Engines are claimed to last 20,000–30,000 hours, or more than 10 years at a typical residential usage rate of 5–7 hours a day. Maintenance requirements resemble those of a car engine: changing the engine oil, spark plugs, and air and oil filters.

Compact cogeneration units can supply a home's electricity as well as heat.

Despite PURPA, some utilities are concerned about widespread use of cogeneration because it reduces electrical demand. In fact, power companies in some areas undermine the economics of cogeneration by charging high hookup fees. Cogeneration advocates argue that by reducing the need for centralized generating capacity—that is, costly power plants—cogenerators actually work in the utilities' favor. "In the long haul," says Tony Williams, president of Micro Cogen Systems (Irvine, Cal.), "the electric utilities will realize we're not a threat." Micro Cogen now makes cogeneration systems producing 20 kilowatts or more of electricity and hopes to introduce a 5-kilowatt unit in a year or so.

Not all multifunction heating systems produce electricity for general use. The triple-integrated appliance—developed by Advanced Mechanical Technology Inc. (AMTI) in Newton, Mass., under sponsorship of the Gas Research Institute (GRI) in Chicago—combines gas-fired, warm-air heating and domestic water heating with electric air conditioning in a single package. The heart of the unit is a furnace that forces hot flue gases to cool rapidly, condense into a liquid, and thus give up most of their heat before being exhausted to the outside. The condensing furnace's relatively cool exhaust gas—110° F, versus 350° from a conventional furnace—can be vented directly through an exterior wall rather than through a vertical chimney. In addition to lowering installation costs, through-the-wall venting makes it possible to install these systems in each apartment of a multifamily building.

Other features of the triple-integrated appliance also raise its efficiency. Combustion, for example, occurs within a sealed compartment submerged within the boiler, thereby minimizing heat loss. Hot water is circulated from the boiler to the hot-water storage tank and through a heat exchanger in an air-handling section. In winter, leftover heat from space heating gets dumped into the hot-water tank; in summer, waste heat from the air conditioner is piped into the tank. This allows the system to achieve overall heating efficiency of 90%. AMTI, along with GRI, is testing the economics and efficiency of the system in 40 demonstration sites, and hopes to offer it commercially in 1988.

Even without integration, a variety of techniques being employed in gas furnaces will increase efficiency beyond the 75–80% levels of conventional systems. Electronic ignition devices eliminate the need for a wasteful pilot flame. "Power burners" force additional air into the combustion chamber to make sure all the fuel burns. Heat exchangers installed in the flue capture heat that would otherwise escape. Several manufacturers—including Bryant, Carrier, and Coleman—now offer furnaces with efficiencies of 80–90%.

Perhaps the most radical innovation is the pulse combustion furnace developed and marketed by Lennox Industries (Dallas). Unlike conventional systems, which use a steady stream of flaming gas, the pulsed unit repeatedly spurts a small amount of gas into the combustion chamber, causing 60–70 mini-explosions per second. The pulsing creates more air turbulence within the combustion chamber; the swirling gases produce more complete combustion, and improve the transfer of

by Jeffrey Seisler



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heat to the heat exchanger. Efficiency of the pulse furnaces is 93–97%. With an average installed cost of $2000–$3000, however, the pulse systems are somewhat more expensive than other high-efficiency gas furnaces. The noise generated by the pulse furnace's rapid-fire explosions can be another problem.

The latest oil furnaces gain efficiency in essentially the same ways as gas furnaces—by recovering as much heat as possible from exhaust gases. The reigning champion is a 91%-efficient condensing furnace from Yukon Energy (St. Paul). Hot combustion gases are passed through a stainless-steel pipe ribbed with aluminum fins; a fan blows air past the fins, cooling the gas to less than 140° F and carrying the heat into the warm-air distribution ducts. The relatively cool exhaust can be vented to the outside with a plastic pipe rather than up a chimney. Consequently, this and other condensing furnaces—either oil or gas—can be installed in the chimneyless homes that were built with electric resistance heating systems.

Other techniques for improving the efficiency of oil heating systems focus on the specific problems associated with a liquid fuel. "Retention head burners," for example, swirl the vaporized oil and air to prolong the fuel's stay in the combustion chamber. The result is a hotter flame and more complete fuel burning. Developed in the early '80s at Brookhaven National Laboratory, these burners are now used in almost all new systems, according to Dick Cahoon, vice-president for policy at the Petroleum Marketers Association of America (Washington, D.C.). In addition, says Cahoon, high-efficiency oil systems use more sophisticated atomizers that inject a fine stream of oil into the burner; by comparison, older units wastefully slosh the fuel into the flame. Another efficiency measure is down-sizing: newer, smaller boilers suffer less from "standby" heat loss than large conventional ones.

Soaring electricity costs have reduced the popularity of central resistance heating systems. But electrical heating is far from dead, thanks to the surging popularity of heat pumps—appliances that efficiently transfer energy between indoor and outdoor spaces. A heat pump can deliver 2–4 times more energy in heat than it consumes as electricity. In the summer a heat pump cools the house by transferring heat from indoors to outdoors.

In their most common application, heat pumps installed outside the house above ground extract heat from outdoor air. The main problem with air-to-air heat pumps is that their efficiency decreases as it gets colder outside; many reach a "balance point" at an outside temperature of about 30° F, when they automatically switch on an electric resistance element. Alternatively, heat pumps can draw heat from water in wells, lakes, or rivers. These systems are more expensive and difficult to install, but maintain their efficiency deep into winter because water stays within a fairly narrow temperature range year-round.

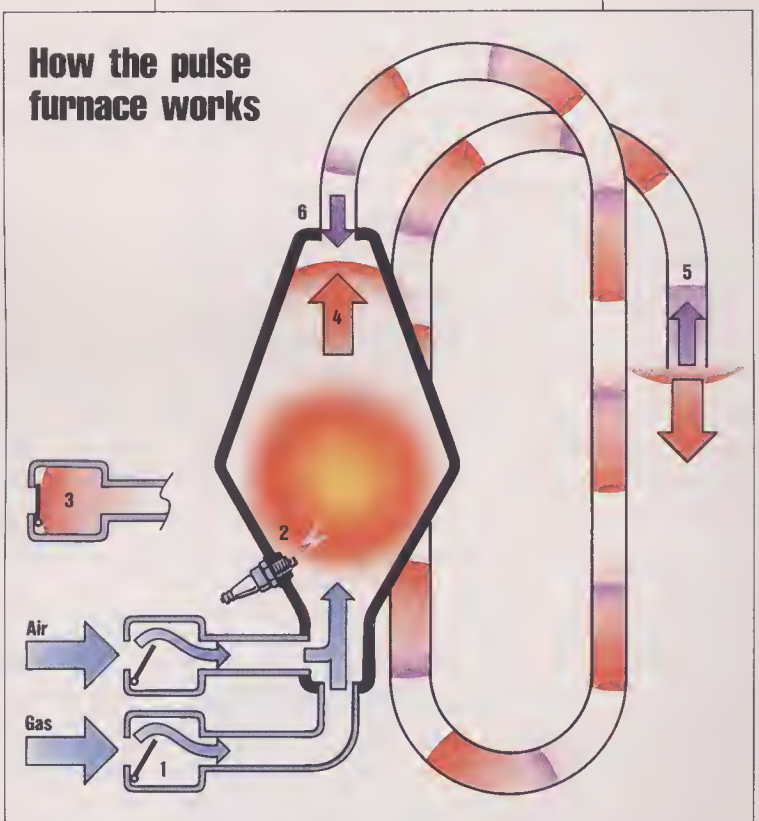
From the perspective of some electric utility researchers, the most fertile area for innovation is in earth-coupled heat pumps, which put the outside heat exchanger in a horizontal trench beneath the frost level. Typically a water or water-and-antifreeze mixture is pumped through buried piping, bringing heat from the earth to the heat pump, where refrigerant running through a heat exchanger transports the heat inside.

"Rural electric systems are really getting excited about earth-coupled heat pumps," says Peyton Collie, a research engineer with the National Rural Electric Cooperative Association (Washington, D.C.). The association is sponsoring experiments to make them about 25% more efficient than they are now by pumping the refrigerant directly into the ground-coupled piping. This would eliminate the need for a heat exchanger within the heat pump itself.

At $6000–$8000 installed, however, earth-coupled heat pumps are about twice as costly as air-to-air systems. Another drawback is the need for a large land area in which to lay the piping. The key to bringing the technology into the city, says Collie, will be to install the pipe vertically in holes drilled to a depth of about 80 feet.

Another heat-pump innovation makes it possible to control temperature independently in different rooms. A Japanese company—Daiken—makes a system that pumps the refrigerant through piping in the house's walls. Wall-hung or floor-mounted condensing units in each room can be adjusted separately to provide zoned heating.

Unfortunately for consumers, political and economic factors have slowed down the introduction of high-efficiency heating systems. Traditionally, many home builders installed relatively inefficient systems, such as electric resistance units; home buyers, it was figured, were more attracted by low initial cost than by the long-term prospect of reduced energy bills. In an action that could have changed the situation, Congress passed legislation last year that would have required all new appliances to meet stringent energy efficiency standards. President Reagan refused to sign the measure into law, but the bill will probably be resurrected sometime this year. □



1) Valves open to let air and gas into the combustion chamber. 2) Spark plug ignites first explosion. 3) Combustion pressure shuts inlet valves. 4) Exhaust pulls valves back open. 5) Pulse is reflected from end of pipe. 6) Reflected shock wave ignites next air/gas charge.

Jeffrey Seisler, manager of natural gas vehicle market development for the American Gas Association, is an energy analyst and freelance writer.

TURNING MICROCOMPUTERS INTO FAX MACHINES

Facsimile machines are becoming common in offices, providing quick, relatively painless transmission of documents. The international Group 3 facsimile (fax) standard provides for transmission of any image—text or graphics—over ordinary telephone lines.

A scanner in the fax machine breaks up the original document into pixels at 200 dots per inch horizontally and 100 dpi vertically (the "fine" mode has 200 dpi in both directions); it then converts the pixels into a bit stream to feed a modem. The receiving fax takes the bit stream and prints the image, usually with a thermal printer, although the most sophisticated units employ laser printers. Fax machines have traditionally been self-contained units, and the smallest are now only a little larger than a typewriter.

Because fax communicates in a digital format, a microcomputer can handle some fax functions better than a fax machine—for example, a computer can store and manipulate a digital image. But a microcomputer needs several accessories—scanner, fax-compatible modem, and graphics printer—to emulate a fax machine completely, and most common scanners and printers sold for micros are not designed for fax applications.

With the appropriate fax software, however, the only essential accessory for adding bare-bones fax to a microcomputer is a fax-compatible modem. The modem has a 9600-bit-per-second (bps) half-duplex protocol (transmissions go only one way at any given time) used mainly for fax; based on a subset of the V.29 protocol, it is incompatible with full-featured V.29 modems, the newer full duplex V.32 modems, and other 9600-bps types. Some fax modem models do permit computer data transmission in a nonfax format to another computer equipped with a similar fax modem. By using a microcomputer to control the modem, some features traditionally found only on expensive fax machines become accessible—for instance, programming the system to make multiple calls overnight when phone charges are low.

by Cary Lu



Without a scanner, fax software must work with information already stored in the computer. The software can synthesize an image of stored text or graphics, which is then sent as if it came from a standard fax machine. Synthesized images, with precisely formed letters and perfect vertical and horizontal lines, are actually much cleaner than scanned fax images, which invariably suffer from paper alignment problems and surface faults that create rough edges and a generally untidy appearance.

On the receiving end, an incoming fax image can be displayed on a graphics screen—but the typical IBM PC screen displays about 50 dpi instead of fax's 200 dpi. Thus you can choose a low-quality rendition at life size, or a quadruple magnification that shows only a small part of a page. In the magnification mode, where one screen pixel corresponds to one fax pixel, images are stretched vertically on most IBM PC screens (where the pixels are rectangular rather than square.)

A printer makes a much better fax output device. Many dot matrix printers have a graphics mode at about 200 dpi, and can thus print a fax image if compatible with the fax software. Yet most impact dot matrix printers sold for microcomputers generate large smudged pixels 11–15 mils in diameter; the image looks much softer than with the thermal printers used by fax machines that produce fairly crisp pixels of 6–8 mils.

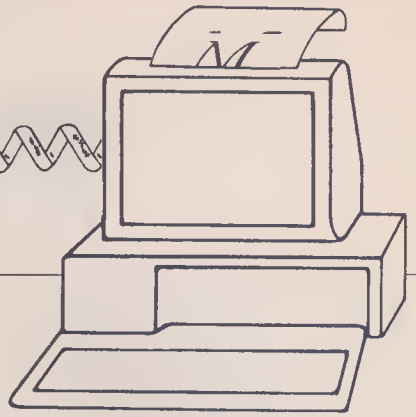
A laser printer can produce even crisper images; the common 300-dpi printers generate 4-mil dots. But there are some problems with reproducing a 200-dpi fax image on a 300-dpi printer. First, the laser printer must be capable of full-page graphics—and most laser printers sold for the IBM PC, such as the Hewlett-Packard LaserJet, cannot do this without expensive hardware add-ons. Second, the software controlling the laser printer must correct the discrepancy between the 200-dpi fax image and the 300-dpi laser image. This can be done with pixel-for-pixel correspondence, in which case the output is two-thirds the original size, or the software can alternate larger and smaller dots to minimize the distortion. The result has some jagged edges, but then Group 3 fax has never boasted high-quality images. New 400-dot-per-inch laser printers can print fax images more easily and are also suited to the new Group 4 400-dpi fax standards.

Scanners attached to a micro for fax input have similar resolution mismatch problems. Most scanners are designed for 300 dpi horizontally, so the controlling software creates a 200-dpi image by ignoring every third pixel. Changing the dpi in the vertical direction is easy since scanners physically move a linear scanning array down the page; software can increase or decrease the scanning rate as required.

Substituting a PC as a fax machine carries some operational implications. A typical fax machine stays on 24 hours a day, connected to a dedicated telephone line. Unless a microcomputer can be devoted solely to fax, the fax software must run in the background while the micro for normal work is run in the foreground. Promising background fax on their PC/fax boards are Datacopy, with its Micro-Fax board and scanner, and Panasonic, with the FX-BM 88 fax board and scanner. But the current versions of MS-DOS are not designed for background functions, so background fax could be disrupted by problems such as routine operator errors in the foreground process.

Another approach to background fax is to put enough memory on the fax modem board to store an incoming message independent from the computer's processor. But how much memory? A receiving fax machine cannot ask the sending machine to pause during transmission so it can dump the images to disk; it can only hang up the phone line. And such memory can be wiped out by power failures.

Yet another way to keep fax running despite microcomputer glitches is to convert a freestanding fax machine by add-



ing a serial port to communicate with a microcomputer; both Pitney Bowes and Xerox sell such units. With suitable software, the 200-dpi fax scanner and printer are available to the computer for nonfax purposes, but unfortunately 200 dpi is too low for desktop publishing and many other applications. Most users will find it better to get 300-dpi scanners and printers and live with the minor problems of running them at 200 dpi. The converted fax units are also expensive—$5000 and up for hardware and software.

For $5000 you can also get a fax machine from Pitney Bowes with a built-in hard disk drive and a multifunction serial port that in fax mode is principally designed for accepting text from a computer. The fax machine takes in text and synthesizes a fax image, and stores it on hard disk for transmission via fax. This setup can send fax images to a PC, but the PC can send only text to the fax.

By comparison, fax accessories for microcomputers cost less. A fax modem board with software sells for under $1200. A low-end scanner attached to an existing dot matrix printer costs only a few hundred dollars; a competent scanner with a 300-dpi sensor array runs about $1500 and up. A dot matrix printer capable of mediocre fax reproduction is only $300, but better ones cost between $600 and $1000. Full-graphics laser printers remain above $3000.

Background operation may not be necessary if you receive fax images only after a voice call to set up the procedure (fax by appointment), or leave fax running only overnight. Fax by appointment has one advantage: publishers have introduced directories of fax numbers. Although a great convenience for fax users, these directories also make "junk fax" possible. Unlike junk mail, a fax message costs the recipient time and money to print the image. Users may begin adopting secure fax networks that accept messages only from authorized senders, but restricted access offsets some advantages of fax.

The major attraction of fax is the ability to communicate with the 2 million fax machines in use around the world. A large portion of these machines are in Japan, where fax has displaced telex and telegrams for sending messages in Chinese characters (kanji); the U.S. and Canada have about half a million fax machines. Group 3 fax works without any fussing over protocols, and it works right now.

But does fax have a future? Despite its digital nature, fax is an unsophisticated technology. In North America, most fax images contain only text, which is much easier to send via electronic mail with character coding than sending pictures of the letters. A recipient can edit electronic text messages, but fax images can be edited only as a bit map, an extremely cumbersome process. In principle, optical character recognition could convert a fax image into a text-editable file, but OCR is impractical on 200-dpi fax images that come from an unknown source. Companies that offer fax OCR should warn prospective buyers not to expect too much. (OCR is easy to use on a synthesized image, but in that case, you may as well have sent the computer file to begin with.)

Since fax images are always pictures, a page can occupy considerable storage—typically 30–60 kilobytes for a page of text, or 120 kB in fine mode, even with Group 3's data compression scheme. A 20-megabyte hard disk devoted to fax images can store just 170 fine-mode pages. As a standard computer file coded in ASCII format, a page takes up only 2–4 kB. Thus an ASCII page at 1200 bps transmits faster than a fax page at 9600 bps.

For graphics, no equivalent to ASCII coding exists, so fax's universality is a great advantage. Nevertheless, a structured graphics file that can be edited by the recipient is far more useful than fax, as it contains lines, text, and other attributes that can be moved as units rather than individual pixels as found in fax.

Future fax developments will concentrate on faster transmission and higher resolution—features that are easily agreed upon internationally—rather than character or attribute coding. The proposed Group 4 standard calls for several resolution levels up to 400 dpi (which should make OCR practical) and an improved compression scheme. Group 4 is designed for an all-digital telephone network instead of dial-up phone lines. (Group 4 does not specify a modem since a digital network does not need modems. Several manufacturers claim to provide Group 4 over dial-up lines, but lacking a standard, these products suffer from incompatibility problems.)

Until an industrywide graphics standard is adopted, fax will remain a practical way to send pictures. And as more microcomputer users add scanners and quality printers for desktop publishing and other applications, fax will become an increasingly common microcomputer accessory as well. Whenever possible, we should be communicating with a good graphics file format from computer to computer, but we may have to live with fax and its limitations for a long time to come. □

Cary Lu is microcomputer editor of HIGH TECHNOLOGY.

COMPANIES COVERED

Datacopy Corp., 1215 Terra Bella Ave., Mountain View, CA 94043, (415) 965–7900.
Panasonic Computer Products Div., Two Panasonic Way, Secaucus, NJ 07094, (201) 348–7000.
Pitney Bowes, Walter Wheeler Dr., Stamford, CT 06926, (203) 351–6127.
Xerox Corp., Xerox Square–06B, Rochester, NY 14644, (716) 423–5078.

OTHER COMPANIES

Carterfone (Cable & Wireless), 1341 W. Mockingbird Ln., Suite 1100W, Dallas, TX 75247, (214) 630–9700. Fax board made by Gammalink.
Electronic Information Technology, 373 Rte. 46, W. Fairfield, NJ 07006, (201) 227–1447. Fax board and scanner.
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INDUSTRY WARMS UP TO MICROWAVE OVENS

Until recently, industrial microwave ovens found acceptance in the rubber and food-processing industries, but they had generally failed to enter other manufacturing sectors. Their use is now expanding, however, as microwave curing and drying moves into several promising areas—in particular, engineering ceramics, semiconductor fabrication, and metal foundries—where conventional heating is less effective. Another new application for industrial microwaves is asphalt recycling, which may play a major role in the growing effort to repair aging American highways.

Conventional techniques generally heat the area around a product, relying on conduction to transmit heat from its surface to its interior. This can be very time-consuming, since heat must penetrate through an object's full cross-section, and the uneven temperature distribution may cause defects such as case hardening, in which an outer skin develops before all internal moisture escapes.

Microwaves heat by creating molecular movement inside an object. As they penetrate, they cause polar molecules (especially water) within the material to align themselves with the electromagnetic field. And as the polarity of the field is alternated, molecules twist repeatedly, generating friction, and therefore heat, evenly throughout the material.

Industrial applications of microwaves have been limited mainly because of their cost—as much as twice that of conventional equipment, says Richard H. Edgar, manager of the Industrial Equipment Group of Raytheon's Microwave and Power Tube Division (Waltham, Mass.). But higher cost takes a back seat in processes such as the drying of superinsulating ceramics where conventional baking just doesn't work. Also, when heating high-cost products such as silicon wafers, the faster cycle time of microwaves may provide significant benefits. Products with high electrical conductivity or with no evenly distributed polar constituents, however, generally cannot be heated by microwaves.

Industrial microwaves are well established in rubber vulcanizing and in certain aspects of food processing because their performance in these areas far surpasses conventional heating methods. To vulcanize rubber, a high temperature is maintained for a set period while molecules interlock to give the material its desired property. But since rubber is a poor heat conductor, it may take more than an hour for conventional heating to generate an internal temperature of 400° F, explains Charles R. Buffler, director of research and applications at Cober Electronics (Stamford, Conn.). Microwaves bring the material up to vulcanizing temperature in about one minute. In a typical vulcanizing application, extruded rubber pieces (like automobile door seals) pass from a microwave tunnel into a conventionally heated chamber, where the temperature is maintained. Rubber makers also use microwaves to preheat material before molding. Not only does the softer rubber prolong mold life, but it also permits faster injection, thereby increasing the production rate, says Buffler.

Microwave heating should gain favor as long-term increases in fuel prices force industries to cut their dependence on gas and oil.

In food processing, microwaves are used primarily for pasta drying and meat tempering, markets in which Microdry (San Ramon, Cal.) and Raytheon, respectively, are leaders. Microwaves evenly warm meat from a deep-frozen state to just below 32° F, where the meat can be processed (diced, ground, etc.) more easily, and then cooled to deep freeze again with minimal energy. In pasta and noodle drying, microwaves prevent the formation of a tough outer skin, and significantly inhibit microbial infestation. Precooking bacon is the most promising new food-processing application. Microwaved prior to shipping, bacon loses much of its moisture without shrinking, and it cooks faster. Thus the fast-food industry, particularly Burger King, is the driving force behind this new use, says Edgar.

An emerging application, "lost-foam casting," extends the established use of microwaves in metal foundries. Conventional metal molds often incorporate cores made of chemically bonded sand that create internal voids and crevices in the finished product; to give a smooth finish to the cores, they are dipped in a ceramic solution, which may be hardened by either conventional or microwave heating. But lost-foam casting, a modern variation on an ancient technique, dispenses with reusable molds altogether and instead uses molds made of foam that evaporates as molten metal displaces it. As with conventional molds, foam blanks must be dipped in a ceramic solution to produce a smooth casting finish; the foam would melt prematurely, however, if the fragile coating were hardened in a high-temperature conventional oven. But because the foam material is transparent to microwaves, only the coating is heated when the microwave process is used.

The most ambitious foundry application to date is a Cober oven for engine-block casting at Ford Motor's plant in Windsor, Ontario, which uses an overhead chain conveyor in a microwave for the first time, says Buffler. To keep microwaves away from the moving metal chain, Cober uses a "choke," or metal deflector, that is specifically shaped and located to intercept the waves. To prevent the microwaves from escaping the oven through the entrance and exit tunnels, Cober incorporates baffles that hang behind every fourth engine-block blank, so several baffles are in the tunnels at one time, blocking stray radiation.

Superwave Technology (Santa Clara, Cal.) is pioneering microwave heating in electronics with its Supertherm line of automated ovens. These systems are designed for a wide range of thermal processing tasks—curing wafer coatings, drying and reflowing solder, and fusing laminated printed circuits, to cite a few. Since many electronic products contain metal, Superwave's "microwave-assisted conduction curing" process uses special

by Jeffrey Zygmont

graphite pallets that intercept most waves as the pallets carry workpieces through an oven; cavities in the bottom of each pallet generate heat and transfer it by conduction to desired parts of the product.

Ovens may be manually loaded, but to complement the trend toward automation in cleanrooms, one Superwave model has robots for loading and unloading wafers. Supertherm ovens range from $35,000 to about $60,000, compared to perhaps $10,000–$20,000 for a convection system. But the increased production rate often justifies the expense, says Nargas Zahedi, an applications development engineer at the company. The ovens reduce curing time from one or two hours to less than six minutes, depending on the application, Zahedi claims.

In ceramic processing, microwaves are still mainly in a developmental stage. But the application is promising, says Raytheon's Edgar: because microwaves heat the ceramic uniformly, they provide more homogenous internal properties; and the near-instantaneous heating from microwaves provides better process control. For example, he notes, "the instant an engineer shuts down the system, the heat begins to leave the product," whereas conventional ovens require a long cooling period. Thus processors can better control steps that are time/temperature dependent, such as grain growth and recrystallization. To tap the market potential of microwaves for ceramic processing, says Edgar, Raytheon hopes to develop a standardized microwave kiln.

The brightest near-term financial prospect is a microwave system for recycling asphalt, according to Robert Nath, chairman of CD High Technology (Georgetown, Tex.). In its first large-scale application, CD's Cyclean system will recycle nearly 500,000 tons of pavement for Los Angeles over the next three years. CD gets $13 per ton, about 60% of the cost of new asphalt, says Nath.

After being torn from a road, recycled asphalt pavement (called RAP in the trade) is fed by conveyor to the oven, where microwaves heat the aggregate (gravel that makes up about 95% of asphalt). By conduction, the aggregate heats the petroleum-based asphalt glue, or bonding material, which is transparent to microwaves.



A view through the top access panel to the heating chamber of Superwave Technology's automated microwave oven shows microchips being bonded to lead frames. Microwaves cure the epoxy in a fraction of the time needed by conventional ovens.

The problem with conventional heating is that the bonder is a very good insulator, which coats every particle of aggregate. Other recycling methods thus require a mixture of at least 50% new asphalt, which must be heated to between 600° and 800° F. It is then added to recycled pavement, which is heated by convection to a final mixture temperature of about 280°, according to Nath.

Such recycling operations must add pollution-control equipment to meet federal EPA emissions regulations, whereas Cyclean is smokeless, says Nath. Also, because the microwave recycler fits on a truck bed, it can be brought closer to a construction site, reducing the expense of transporting asphalt.

Despite these developing applications, industrial microwaves remains a small industry, a state Raytheon's Edgar blames on its commitment to customized systems that cannot be adapted to multiple users. Most observers estimate that combined annual sales for the handful of U.S. companies are in the neighborhood of $15 million. The four largest companies are Cober, Microdry, Raytheon, and Gerling Laboratories of Modesto, Cal.

But in its recent report *U.S. Commercial and Industrial Microwave Equipment Markets*, Frost & Sullivan predicts that microwave heating will gain favor as long-term increases in fuel prices force industries to cut their dependence on gas and oil. It cites two factors that should contribute to increased awareness of microwave processing in industry: the wide acceptance of home microwaves, which have become high-volume, commodity products; and the availability of combined microwave/conventional ovens, like the Cober Cure oven, which is both a high-velocity hot-air tunnel and a microwave chamber, permitting the two modes to be used interchangeably or together, thereby exploiting the advantages of each. Such combined units familiarize processors with microwaves while providing the security of tried-and-true methods. □

Jeffrey Zygmont is a senior editor of HIGH TECHNOLOGY. *George Svenson, a writer in Watsonville, Cal., contributed to this article.*

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PERSONAL WORKSTATIONS, p. 18

"Computer workstation architecture: 1982–1992." William Joy. *New Frontiers in Computer Architecture Conference Proceedings.* March 16–19, 1986. A detailed but cryptic account of hardware and software trends in workstations. Report NT-1, available from Citicorp/TTI, 3100 Ocean Park Blvd., Santa Monica, CA 90405, (213) 450–9111.

"The evolution of workstations." David L. Nelson & C. Gordon Bell. *IEEE Circuits & Devices Magazine,* July 1986. History of workstations with some interesting projections of performance and costs. Copies available through IEEE publications sales office, (201) 981–1393.

"Workstation graphics and productivity." Paul Henderson. *Machine & Tool Blue Book* (Wheaton, IL), June 1986. How workstations are being used from mechanical engineering design.

"Disk makers seek workstation access." Anne Knowles. *Electronic Business,* Nov. 15, 1986. A look at the market for storage products for workstations.

"Shifting to workstations; users discover expanding capability." John Teresko. *Industry Week,* Nov. 10, 1986.

"It's high noon for work-station makers." Craig D. Rose. *Electronics,* March 17, 1986.

MANAGING COMPUTER NETWORKS, p. 24

"An analysis of IBM's netview/PC: Potential, potential, potential." Lee Mantelman. *Data Communications,* Nov. 1986. Detailed examination of the IBM product, including its SNA genealogy, its limitations, and its chances for success.

"Avoiding network tie-ups." Charles G. Teets. *Computerworld Focus,* Sept. 17, 1986. Examines network management at three levels: small local-area networks (LANs), large LANs, and wide-area networks.

"New IBM SNA uses outside and voice gear." Richard Diennor. *Electronics News,* Sept. 22, 1986. Announcement of Netview/PC, discussion of its features.

"Network processors: Positioned to manage." Richard S. Amster. *Data Communications,* Oct. 1986.

"Need for net management tools growing." Laurie Flynn. *Infoworld,* Dec. 1, 1986.

THE PENTAGON'S WAR ON COSTS, p. 31

Contact

U.S. Air Force Electronic Systems Div., Hanscom Air Force Base, MA 01731, (617) 377–4064. Mary Farris.

References

"Escaping MIL-standards at the Air Force's ESD." Michael Kachmar. *Microwaves & RF*

(Far Hills, NJ), Aug. 1985.
"Air Force's competition advocacy program aims at subcontractor tier." Herbert J. Coleman. *Aviation Week*, Dec. 23, 1985.
"Competition: A Pentagon battlefield." Bill Keller. And "Bidders and Congress join in the fray." Winston Williams. *New York Times*, May 12, 1985.
"Pentagon competition policy producing spare parts savings." Paul Proctor. *Aviation Week*, May 26, 1986.
"Why systems command seeks 'efficiency,' not just 'contract competition.'" *Government Executive* (Wash., DC), July/Aug. 1984.
"Team efforts win favor at Pentagon, but doubts emerge." Ralph Vartabedian. *Los Angeles Times*, Nov. 9, 1986.
"Defense profits under pressure." John M. Barry. *Dun's Business Month*, Nov. 1986.
"The trouble with defense contractors." Richard Halloran. *New York Times Magazine*, Dec. 8, 1985.
"The carrot, not the club." Subrata N. Chakravarty. *Forbes*, Aug. 26, 1985.
"New productivity incentive for defense contractors." James W. Stansberry. *Harvard Business Review*, Jan./Feb. 1985.

GALLIUM ARSENIDE ON SILICON, p. 38

VLSI Electronics Microstructure Science. Norman Einspruch, ed. Academic Press, Orlando, FL, 1985. Vol. 11 of this definitive series on microelectronics is devoted to gallium arsenide. Covers materials, devices, packaging, testing, and applications. Technical but readable.
"Heteroepitaxy on silicon." J. C. C. Fan & J. M. Poate, eds. *Proceedings of the 1986 Materials Research Society* [Pittsburgh, PA] *Symposium, Vol. 67.* Deep, required reading for anyone with detailed, technical questions about gallium arsenide on silicon.
"Gallium arsenide chips emerge from the lab." Gregory Johnsen. *High Technology*, July 1984. Nontechnical discussion of the gallium arsenide devices that might be built on silicon substrates.
"Ultrafast chips at the gate." Herb Brody. *High Technology*, March 1986. Introduction to the techniques used to deposit one semiconductor film onto another. Discusses some of the new devices that result.

JAPAN'S COMMERCIAL AIRCRAFT, p. 42

"Japan bids for a seat in the airline business." Bob Johnstone. *New Scientist*, Oct. 24, 1985. An analysis of negotiations for the 7J7 airliner project.
"Japan's FS-X decision." Kensuke Ebata. *Jane's Defence Weekly*, Aug. 9, 1986. A look at Japan's options for its next-generation support fighter."
"International projects as keys to Japan's aircraft industry." Neil W. Davis. *The Japan Economic Journal*, Aug. 9, 1986. First of a series on Japanese aircraft technology development.

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STAYING IN TOUCH WITH SUBS

While submarines are very difficult to detect at operating depth, they are also very difficult to contact. To receive conventional radio transmissions, which penetrate only a few meters of seawater, subs must interrupt their normal operations to approach the surface and thus greatly increase their risk of detection. But two new technologies now offer submarines the prospect of receiving communications while deep in the ocean. The ELF (extremely low frequency) radio system, which started full operation last year, uses exceptionally long wavelengths that penetrate seawater to great depths. The SLC (satellite laser communication) approach, currently under vigorous research, uses a blue laser beam to pierce the water. Together, these complementary methods offer the prospect of flexible and versatile communications for the subs of the 1990s, with ELF providing precoded messages to the fleet as a whole and SLC sending emergency communications meant for individual missile subs.

ELF, which the Navy started to develop in the 1960s, relies on the principle that low-frequency waves can penetrate much farther into seawater than can high frequencies. Conventional naval radio, transmitting at a few tens of kilohertz, reaches a depth of 10 meters. ELF operates between 72 and 80 hertz and extends down hundreds of meters.

An ELF antenna, which transmits signals that travel first through the air and then down into the ocean, relies on rocks. To produce a detectable signal, the antenna must form a loop in the vertical plane several miles across, shaped like the letter D or O. This requires an electric current that runs along cables near the earth's surface and dives deep into the bedrock to create the rest of the loop. In order to drive the current to the lowest possible depths—and hence achieve the strongest possible signal—the bedrock needs particularly high electrical resistance. The dry impermeable granite that best satisfies this requirement exists in relatively few places in the U.S.; the Navy chose the region of northern Wisconsin and Michigan's upper peninsula.

by T. A. Heppenheimer

In 1982, after the Navy scaled back its original demands for space in response to local protests, a $231 million ELF system won government approval. The main construction contract, for $121 million, went to GTE Government Systems (Needham, Mass.), which is also supplying submarine receivers containing a signal-processing computer from Sperry. The two ELF transmitters, featuring 28 and 56 miles of transmitter cable mounted from poles like telephone lines, are based respectively in Wisconsin's Chequamegon National Forest and 150 miles away at a site close to Michigan's K. I. Sawyer Air Force Base, where the system's control center is located.

The antennas are inherently inefficient;

Two new technologies promise effective communications with submarines at great depths.

1.35 megawatts of input electrical power produces ELF radio waves with just 2 watts of power, which severely limits transmission speed. Thus the system transmits only three-letter coded messages that are highly standardized commands—BCJ, for example, means "the system is operating normally but there is nothing to communicate"—or that alert a sub to come up for more. Nevertheless, the system has proved its value to the small number of subs in which it has already been installed. In fact, the Navy expects the combination of ELF and conventional radio, beamed from shore and airborne transmitters, to serve its near-term needs.

In recent years the Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., has taken the lead in developing technology for the altogether different SLC system. The program got its start in DARPA's Directed Energy Office in the late 1970s, as an offshoot of efforts to produce powerful lasers for strategic defense.

One of DARPA's proposed devices would use a xenon chloride laser, one of a class of "excimer" lasers that offer reasonably high efficiency. Although xenon chloride's ultraviolet light does not penetrate seawater, its wavelength can be shifted using the "Raman effect," in which the beam stimulates the atoms of an appropriate material to emit light. Using hydrogen as the material, engineers created an efficient system that produced a vivid blue-green beam of light that could reach considerable ocean depths.

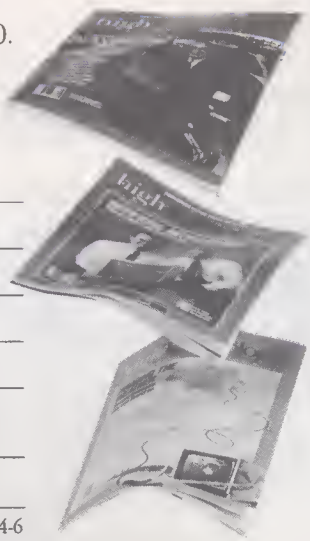
Detecting the light, however, was a problem. Designers needed a laser receiver that could see an incoming beam over a wide range of angles—since a message could come in from almost any direction—and yet would respond only to the wavelength of the weak and scattered laser light. Standard optical filters could not fulfill both requirements: the narrowband type could only take in a small range of angles, while the wide-angle design responded to a spectral range so broad that it could not distinguish the laser light. The only apparent compromise was to demand high laser power: kilowatts for a space-based laser, hundreds of watts from an aircraft, or tens of kilowatts for a ground-based system reflecting off an orbiting mirror. Since scientists saw no immmediate prospect of such power levels, the blue-green laser was expected no earlier than the late 1990s.

Then, in 1983, two years after DARPA director Robert Cooper sponsored a major effort to seek new approaches for the receiver, the University of Arizona unveiled a cesium vapor receiver filter that relied on atomic effects rather than classical optical techniques. Photons of laser light excite the cesium and cause its atoms to fluoresce, emitting deep-red light that, when demodulated, yields the message carried by the laser. The cesium responds only to a very narrow range of wavelengths, but can readily offer wide-angle reception. The new filter, according to Donald Latham, assistant secretary of defense for communications, "offers a several-hundred-foot increase in the depth achievable, or a factor-of-fifteen decrease in message delivery time, or a [classified] decrease in the amount of laser power." It also brought a shift in terminology. Since the cesium receiver couldn't pick up blue-

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ters in diameter on the ocean surface, and was detected by laser receivers aboard the submarine U.S.S. *Dolphin*, riding at a classified depth. Significantly, the tests used conventional laser receivers rather than the much more sensitive cesium filter. Nevertheless, the beams propagated successfully through towering thunder-

length, but Varian Associates (Santa Clara, Cal.) and ITT (Fort Wayne, Ind.) are developing devices based on gallium arsenide that offer at least 10 times better detection efficiency.

The DARPA program, now running at about $30 million annually, is developing both airborne and satellite-borne lasers.

curity, because their directional beams will be much more difficult to tap than are today's omnidirectional radio transmissions. □

T. A. Heppenheimer, a freelance writer based in Fountain Valley, Cal., has a PhD in aerospace engineering.

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ticularly high electrical resistance. The dry impermeable granite that best satisfies this requirement exists in relatively few places in the U.S.; the Navy chose the region of northern Wisconsin and Michigan's upper peninsula.

by T. A. Heppenheimer

lington, Va., has taken the lead in developing technology for the altogether different SLC system. The program got its start in DARPA's Directed Energy Office in the late 1970s, as an offshoot of efforts to produce powerful lasers for strategic defense.

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MARILYN CATHCART

Scanning the ocean in preset patterns, orbiting blue lasers will send emergency messages received from ships and shore stations to submerged submarines.

green light, designers substituted lead vapor for hydrogen in the Raman. The result was a blue beam and a "blue laser." At the same time, DARPA decided to transmit the messages with satellite-borne, rather than ground-based, lasers, because studies showed that they could obtain similar coverage with less power.

Airborne tests in 1984 demonstrated how lasers can pierce heavy clouds and dirty seas. A 1-watt laser from GTE mounted in a Rockwell International Sabreliner illuminated a spot several kilometers in diameter on the ocean surface, and was detected by laser receivers aboard the submarine U.S.S. *Dolphin*, riding at a classified depth. Significantly, the tests used conventional laser receivers rather than the much more sensitive cesium filter. Nevertheless, the beams propagated successfully through towering thunderheads off Oregon and through roiling, turbid water off California's San Clemente Island. In the words of a DARPA official, "The depths that we reached are astonishing, and classified."

In the past two years, McDonnell Douglas and GTE Government Systems have built cesium filters, and GTE is now building a complete receiver for a submarine. The next problem is detecting the individual photons of deep-red light that emerge from the fluorescing cesium. Conventional detectors work poorly at that wavelength, but Varian Associates (Santa Clara, Cal.) and ITT (Fort Wayne, Ind.) are developing devices based on gallium arsenide that offer at least 10 times better detection efficiency.

The DARPA program, now running at about $30 million annually, is developing both airborne and satellite-borne lasers. The airborne types would be used for future experiments; the orbiting lasers would scan large areas of ocean from geosynchronous orbit, perhaps in a predetermined pattern designed to provide uniform coverage of large areas. Lockheed Missiles and Space (Sunnyvale, Cal.) is designing the satellite, called SLCSAT, and Northrop (Century City, Cal.) has built the laser, which DARPA describes as "space-qualifiable." It must operate untended for five to seven years in orbit. HLX Lasers (San Diego), an offshoot of the now-defunct Helionetics, plans to undertake accelerated testing by using a version that can pulse at a particularly high repetition rate. Mathematical Sciences Northwest (Seattle) has also devised methods to prolong laser life.

The next round of tests will take place in 1988, when an airborne blue laser built by HLX will transmit to GTE's sub-mounted receiver. At that point DARPA will transfer the program to the Navy, which will decide whether or not to develop the system for operational use. The Navy probably won't move full speed ahead initially. The Pentagon's Donald Latham has estimated that the blue laser will cost from $700 million to $2 billion, but the Navy plans to spend only $100 million between 1987 and 1992. Much of the Navy's communications budget is currently devoted to upgrading the aircraft that would be used for wartime transmission of emergency messages to missile submarines. This program will continue until late 1991. At that point, the blue laser may really see the light of day.

If the blue laser goes into operation, communications experts expect it to complement ELF. The Navy will continue to use ELF as its bell ringer, to deliver precoded routine messages to the submarine fleet. Blue lasers will take over from transmitter aircraft the task of sending emergency commands meant for missile subs. In that role, they will offer extra security, because their directional beams will be much more difficult to tap than are today's omnidirectional radio transmissions. □

T. A. Heppenheimer, a freelance writer based in Fountain Valley, Cal., has a PhD in aerospace engineering.

AI AIDS COMMUNICATIONS NETWORKS

Tracking faults in the telephone network can be like trying to find a needle in a haystack. AT&T estimates that until recently, five years of training was needed to learn how to sift through pages of computer data to diagnose the abnormal patterns that indicate faults. But AT&T's Bell Laboratories (Short Hills, N.J.) has now come up with Automated Cable Expertise (ACE), an expert system that embodies the experience of faultfinding experts, along with data about the workings of the network, to simplify matters considerably. ACE scans the cable repair database, locates trouble spots, and determines their causes in a few minutes. The ACE system is just one of several artificial intelligence systems for network design, control, and management that are beginning to move out of R&D and into the workplace.



BBN's Designet AI system uses color graphics to help network designers experiment with various configurations, and calculates cost and utilization rates for each network.

Bell Laboratories is working on other expert systems for network diagnosis and control. One system, called Nemesys (Network Management Expert System), will reduce congestion on AT&T's long-distance telephone network. Nemesys will take information on uncompleted calls and determine why they were blocked, and will suggest ways for network operators to reroute them. Another Bell Laboratories expert system, Trouble Shooter, will allow a relative novice to find and diagnose problems in the new central office–based local-area networks now being marketed by the telephone companies.

For private communications networks, the Net/Adviser from Avant-Garde Computing (Mount Laurel, N.J.) works as an aid to network control in conjunction with a conventional monitoring system called Net/Command (see "Managing computer communications," p. 24). Net/Adviser is a rule-based system that receives network information in the form of situation alerts that show where congestion is occurring; it then informs the controllers of ways to reroute calls in order to resolve those problems. In its present form, Net/Adviser only offers advice to the user, but the company plans to make it control the network directly and reroute calls automatically.

At BBN Communications in Cambridge, Mass., AI is used in the Designet program, which employs color graphics that allow the network designer to experiment with various configurations to determine the loading and costs for alternative networks. The initial input for Designet comes from user surveys made by BBN engineers, but the company plans to replace this "knowledge acquisition" stage with an expert system that will enable potential users to describe their network requirements directly to Designet.

Another system for monitoring network malfunctions is the Real Time Expert Analysis and Control Tool (REACT), under development in Livingston, N.J., by Bell Communications Research (Bellcore)—the research arm of the "Baby Bell" companies. REACT helps network controllers in telephone companies detect and resolve problems that usually must be handled by expert consultants. REACT will monitor alarms coming in from the network, and will suggest corrective action.

Other companies using artificial intelligence techniques for communications network analysis include GTE (Stamford, Conn.), which has a system for analyzing its electronic switching systems, and Digital Equipment (Maynard, Mass.), which has an expert system called the Network Troubleshooting Consultant that helps solve customers' local-area networking problems.

For the moment, artificial intelligence techniques for network analysis will be used mainly by the telephone companies and the few large businesses that have major private networks. Software prices are high—tens of thousands of dollars—and large computers or specialized workstations are required to run the programs. But generalized software development tools for expert systems are now becoming commercially available so that AI systems need no longer be developed from scratch. With such tools, less expensive expert systems can be developed that will run efficiently on the more powerful personal computers, such as Compaq's DeskPro 386, just entering the market. As the cost of developing artificial intelligence software declines, expert network analysis and control systems will more than likely become available to any company with a private network, rather than just to the large telephone companies. □ —*Lawrence Gassman*

TURNING ANTIBODIES INTO CATALYSTS

Using a new biotechnology tool, two research groups have recently endowed one type of protein, antibodies ("abs"), with the chemical properties of another, enzymes. The resulting "abzyme" process is now being studied for commercialization by IGEN in Rockville, Md., and could result in a simple and efficient new method of designing and producing proteins for cancer treatment, genetic engineering, and chemical processing.

Enzymes are catalysts that act as a sort of stage on which chemicals come together to form new products. About 2000 natural enzymes are known, and many of them are vital to the chemical, food-processing, and pharmaceutical industries. An enzyme contains a three-dimensional pocket into which the reactants' high-energy intermediate forms (called their transition states) fit snugly; such "docking" stabilizes the transition states and lowers the reaction's energy needs so that it proceeds faster—in some cases, hundreds of millions of times faster—than if uncatalyzed. One example is the blood-cell enzyme carbonic anhydrase, a single molecule of which catalyzes 36 million reactions per minute. (The enzyme converts carbon dioxide from the tissues into the more soluble carbonic acid, then back to carbon dioxide in the lungs so it can be exhaled.)

Antibodies are generated by the immune system in response to an antigen (a foreign cell or chemical), and work by a similar mechanism. That is, a portion of the molecule precisely fits the pattern of molecules jutting from a specific antigen, and in the process signals other immune-system cells to destroy the antigen.

These similar modes of action have led many researchers to wonder if antibodies (which assume a virtually unlimited number of shapes, depending on the antigenic "template") could serve as catalysts. All one would have to do is inject a laboratory animal with a specific transition-state molecule and let the creature's immune system manufacture an antibody molded to fit that molecule. The resulting abzyme would thus be able to catalyze the corresponding reaction. That approach, however, has only recently become feasible with monoclonal antibody technology, in which the cell generating an antibody against a specific antigen is isolated from millions of other similar cells, and then cultured to produce large volumes of the antibody.



DANIEL FORT

Immune-system proteins that mimic enymes could catalyze medical and industrial reactions, says Scripps's Alfonso Tramontano.

At least one potentially useful abzyme has been developed at the Research Institute of Scripps Clinic (La Jolla, Cal.). Molecular biologists Alfonso Tramontano, Kim D. Janda, and Richard A. Lerner (a member of IGEN's scientific board) injected mice with a chemical (called a phosphonate ester) that is similar in shape to, but more stable than, a transition-state molecule in a reaction called ester hydrolysis. As expected, the phosphonate prompted production of antibodies in the mice. The researchers isolated the antibodies and found one that speeded up the hydrolysis by 1000 times—rather slow compared to the millionfold capabilities of enzymes like carbonic anhydrase, but exciting nevertheless. "Some people think that to be useful, an enzyme must speed a reaction by 100 million times or so," says Tramontano. "But if there's a reaction for which there is no existing enzyme, then moderately increased rates are useful."

Results were even more dramatic at the University of California (Berkeley), where chemists Peter G. Schultz, Scott J. Pollack, and Jeffrey W. Jacobs used an antiphosphonate antibody to speed ester hydrolysis some 15,000-fold. The group has since made other antibodies that provide similar results in other reactions.

One of the first commercial uses for abzymes will probably be to alter other proteins that, like abzymes themselves, consist of chains of amino acids. For example, it may be possible to design antibodies that mimic enzymes called proteases, which cut proteins at specific amino-acid sequences. Today's proteases often lack the required specificity, and cut proteins at unpredictable sites, according to Tramontano.

Healthcare offers several potential uses for new proteases. One designed to cut the protein fibrin (the major component of blood clots) may be useful in treating heart disease by dissolving the clots, as some enzymes are known to do. Stelios Papadopoulos, vice-president for biotechnology at Drexel Burnham Lambert (New York), suggests that others could treat cancer by homing in on the proteins that protrude from malignant cells, a process that might fatally damage the cell membrane. And an abzyme that recognizes and breaks a specific amino-acid segment in viruses might prevent them from binding to target cells.

Tramontano doubts that the abzyme technique will completely replace such methods as fermentation and chemical synthesis, which already produce large numbers of enzymes efficiently; but the process could complement those methods by providing new antibodies to speed up reactions that are now uncatalyzed. The Scripps team is now trying to enhance the abzymes' selectivity and reactivity—by adding organic or metallic groups, for example, which are known to increase the attraction of some natural enzymes to certain molecules. □ ***—Ricki Lewis***

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EPITAXX:

Seeking niches in optical communications

Epitaxx, a semiconductor electronics manufacturer, produces light-emitting diodes, lasers, and photodetectors for fiber optics and infrared instrumentation. Using a proprietary crystal growth technique called vapor phase epitaxy (VPE), in which the elements to be deposited are introduced as gases, Epitaxx produces high-quality wafers of indium gallium arsenide phosphide (InGaAsP); devices made from these materials can emit and detect light at wavelengths that incur the lowest signal degradation over fiber optic links. Most competing companies use liquid phase epitaxy, which Epitaxx claims is slower than VPE and thus not as well suited to mass production. The company also uses VPE to manufacture InGaAs-based detectors for products such as optical power meters and laser range finders.

Epitaxx sells its components to telecommunications vendors such as GTE and ITT, and to fiber optics companies such as Fibercom and Plantronics Wilcom. Competitors include RCA, Laserton, Fujitsu, and NEC.

Financing: $1.5 million in first-round venture capital from Warburg Pincus and DSV Partners.

Management: Cofounders Gregory Olsen (president) and Vladimir Ban (executive VP) were research scientists at RCA David Sarnoff Research Laboratories in Princeton, N.J., where they developed VPE applications.

Location: 3490 U.S. Route 1, Princeton, NJ 08540, (609) 452–1188.

Founded: March 1984.



Epitaxx's Greg Olsen (left) and Vladimir Ban, with a reactor used to produce fiber optic components.

ARIES TECHNOLOGY:

Engineering workstations simulate prototypes

Aries Technology markets a desktop computer tool, the ConceptStation, for helping mechanical engineers create "software prototypes"—3-D geometric models that can be tested on the computer. Such a system not only reduces the number of expensive hardware prototypes necessary for design verification, but simultaneously produces 3-D databases that can serve in later phases of product development and that can eventually be used to program manufacturing machines directly.

Aries sells the ConceptStation in both a bundled version, including all the necessary hardware and software, and an unbundled version, which runs on IBM PC/ATs and is enhanced with a proprietary 32-bit 8-megaflops applications accelerator and graphics engine.

Financing: $17.5 million in venture capital from investors including Cummins Engine, Prutec, ABS Ventures, Eastech, and First Capital Corp. of Chicago.

Management: Larry McArthur (president and CEO) was president and cofounder of Maxitron, a manufacturer of factory automation systems. Gerald N. Christopher (cofounder, treasurer, and VP of finance and operations) was treasurer and VP of finance and administration at Davox, a producer of integrated voice/data workstations. William Arthur McCray (cofounder and VP of software development) was VP of CAD/CAM Consulting Group.

Location: 650 Suffolk St., Lowell, MA 01854, (617) 453–5310.

Founded: November 1984.

PRODUCTIVITY PRODUCTS INTERNATIONAL:

Software for writing software

Productivity Products International (PPI) has developed a software technology based on a proprietary language known as Objective-C (a "superset" of C). The language allows programmers to combine programming code into reusable components called software ICs that can be mixed and matched, much as hardware ICs are assembled on a printed circuit board. An interpreter for Objective-C called Vici allows software engineers to debug, test, and build prototypes for applications such as CAD/CAM, AI, and simulation. PPI predicts that the most immediate impact of this technology will be on the design of icon-based graphics interfaces, which are costly and difficult to build using standard programming techniques.

PPI's customers include Hewlett-Packard, General Motors, Siemens, Ericsson, Accuray, NASA, and Lawrence Livermore Laboratories.

Financing: Undisclosed seed capital from company principals, $2.5 million in first-round venture capital from Oak Investment Partners, Lawrence Associates, Norstar Venture Capital, and Utech.

Management: Tom Love (chairman and cofounder) was corporate director of advanced programming technology at ITT, Dennis Sisco (president) was VP of operations at Data Switch, Brad Cox (cofounder, VP, and chief technical officer) was a senior member of the technical staff at ITT, and George Sampson (VP of engineering) was product director of switching for ITT's Defense Communications Division.

Location: 27 Glen Rd., Sandy Hook, CT 06482, (203) 426–1875.

Founded: June 1983.

—Margaret Woisard

BIOTECH INSTRUMENTATION: A PROFITABLE NICHE

Investing in biotech firms is still somewhat risky; most of them face little or no near-term earnings because of the time required for R&D, clinical testing, and regulatory approval of new products. But companies that provide research equipment and supplies to these firms do offer a profitable investment area.

Prospects for market growth in biotech supplies are based on two factors. Any biotech laboratory must have equipment suitable for handling and analyzing the fragile materials (such as tissues, cells, and proteins) involved in its research. And the size of budgets devoted to biotechnology R&D is growing, particularly as government agencies and large pharmaceutical, agricultural, and chemical firms such as Eli Lilly, Johnson & Johnson, Monsanto, and Du Pont enter the field.

In the past three years, several instruments that increase the efficiency of biotech research have reached the market. For example, protein sequencers (instruments used to analyze the composition of proteins) and DNA synthesizers (instruments that can automatically build customized DNA chains) have enabled scientists to quickly identify and mass-produce genes of interest. In addition, general-purpose analytical instruments, such as liquid chromatographs and electrophoresis equipment, have been substantially improved and optimized for the needs of the biotechnology researcher. The market for these types of instruments and related supplies is currently about $450 million, a figure that should double within four years, according to L. F. Rothschild, Unterberg, Towbin (New York).

A number of large companies, including Du Pont and SmithKline Beckman, have traditionally supplied equipment to biological laboratories. But several more specialized firms—including Applied Biosystems (Foster City, Cal.) and Pharmacia (Uppsala, Sweden)—have developed reputations for successfully marketing innovative products specifically directed to the needs of biotech R&D.

Applied Biosystems (OTC: ABIO) is the leading supplier of automated chemistry instrumentation to biotech laboratories. The company's strategy has been to offer products generally selling between $50,000 and $100,000, that increase the efficiency of crucial, repetitive biochemical procedures. For instance, this year the company will be the first to introduce a device that automates the biochemical analysis of DNA to determine its genetic code, probably the most commonly performed procedure in molecular biology labs today. Other processes automated by the company's most recently introduced products include the analysis of numerous samples for their amino acid composition, and the extraction and purification of DNA from blood, tissue, or other biological materials.

Revenues in fiscal 1986 were $51.7 million, with profits of $10.4 million and 78¢ earnings per share. These figures should climb in 1987 to an estimated $90 million in revenues, $14 million in profits, and earnings per share of $1.04.

Pharmacia (OTC: PHABY) is the leading supplier of materials and equipment used to purify proteins and other large molecules by liquid chromatography, a technique that separates molecular mixtures into pure samples. The company is well entrenched in research labs, which use its systems for purifying small amounts of protein for experimental purposes. Because virtually all products of genetic engineering are proteins, Pharmacia now faces a major growth opportunity as its customers move to commercial production. Anticipating such growth, the company recently created a division to cater to large-scale users. In addition, Pharmacia has formed a joint venture with Alfa-Laval, another Swedish firm, to offer specialized fermenters and other production equipment for use in manufacturing genetically engineered products.



Applied Biosystems manufactures a variety of biotech instruments, including the protein sequencers shown here.

Pharmacia's revenues are estimated to have climbed from $400 million in 1985 to $520 million in 1986; some 30% of this business is derived from biotech supply, and the remainder from pharmaceuticals, hospital supply, and diagnostic products. Profits are also estimated to have risen in this period from $73 million to $90 million, and earnings per share from $1.10 to $1.40. For 1987, the picture is less clear because the company is now making several major acquisitions; once these are completed, opportunities for growth should be strong. □

by Teena L. Lerner

Teena L. Lerner is a vice-president at L. F. Rothschild, Unterberg, Towbin (New York), where she covers biotechnology stocks.



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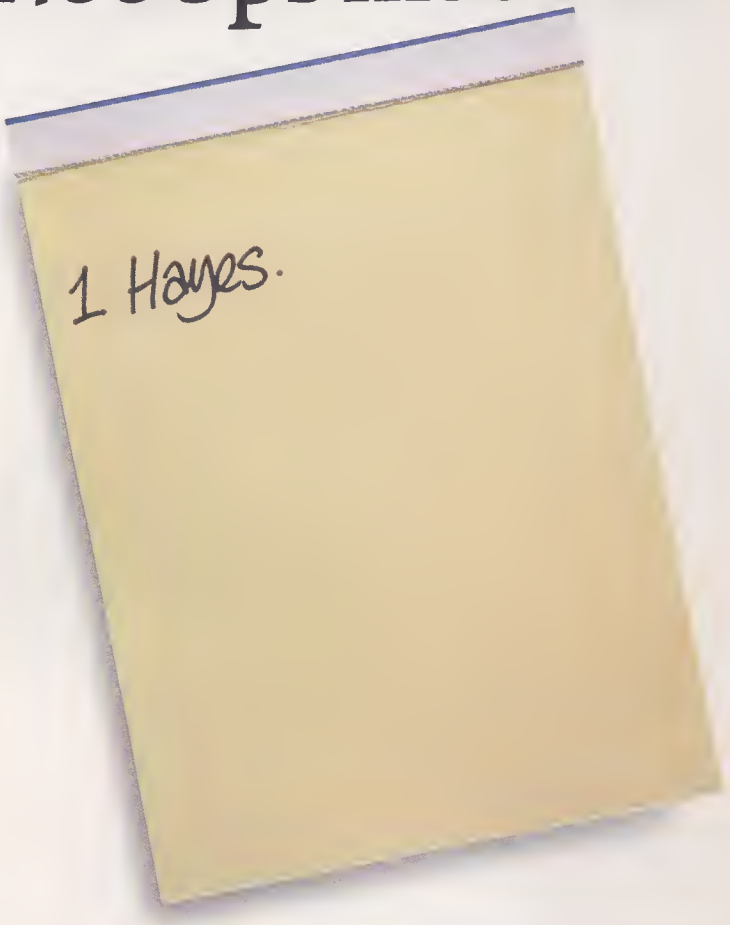
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